POWER

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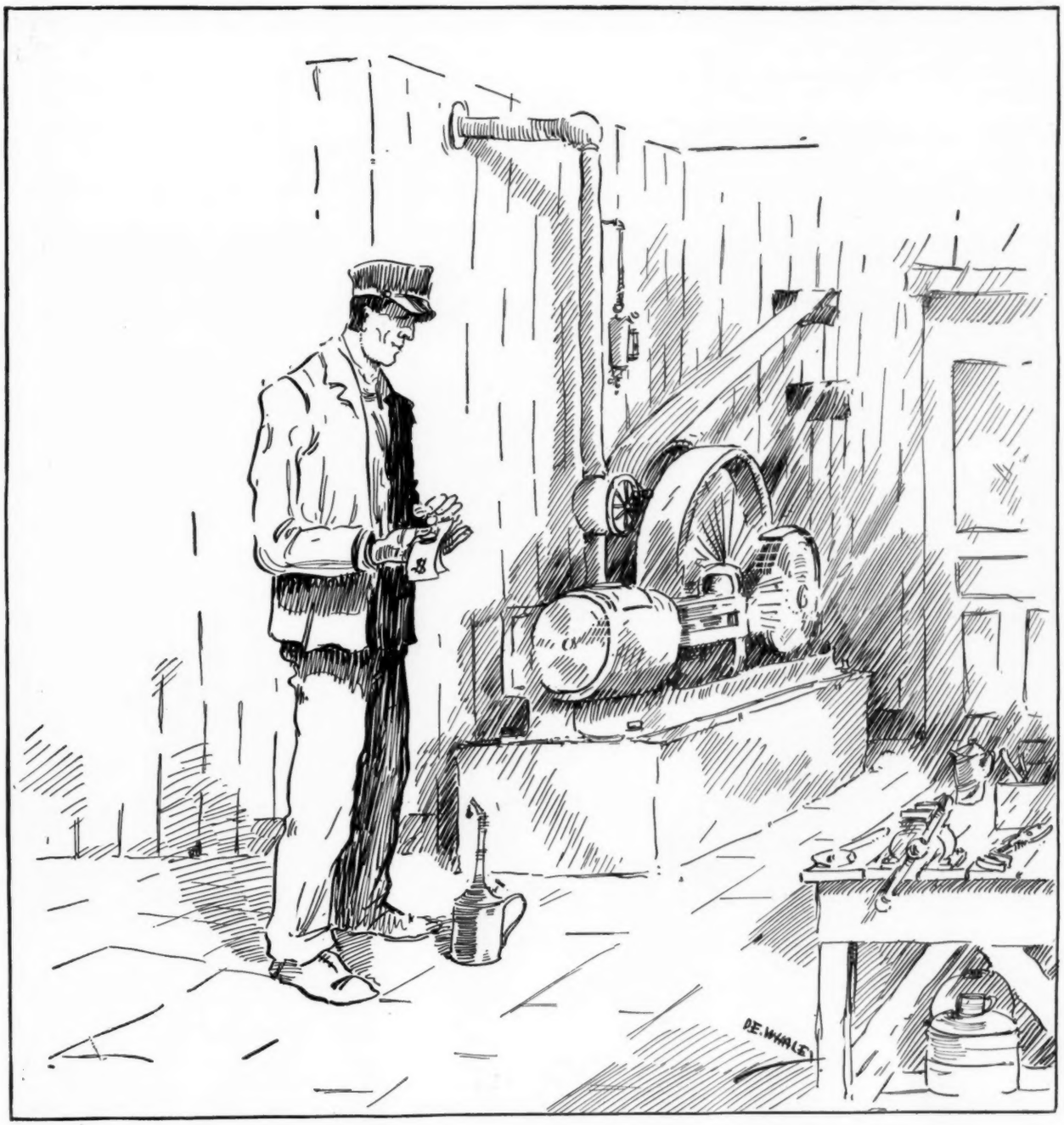
Causes of Failure



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Air-Balanced Hoisting Engine

SYNOPSIS—A hoisting engine that uses a mixture of compressed air and saturated steam during the hoisting period. To each of the two steam cylinders is attached an air compressor cylinder in which air is compressed to 95 lb. pressure as the skip is lowered into the mine. The engine uses a mixture of air and steam upon starting to hoist and changes to steam when the pressure in the air receivers is reduced to 65 lb.

At the Franklin Junior copper mine of the Franklin Mining Co., at Boston, Mich., is a combined steam and air hoist for handling the skip in the single shaft that is 3,700 ft. deep. Usually a double-compartment shaft is used at copper mines with two skips, one being at the top when the other is at the bottom of the shaft, and each counterbalances the other. It is the opinion of some that a single-compartment shaft on long lifts is advisable, but in order to operate a single-shaft hoist economically some kind of balanced hoisting engine must be used. Although this air-balanced hoisting engine is more complicated than the ordinary type, it utilizes the power developed by the descending skip by using air that is compressed during such periods.

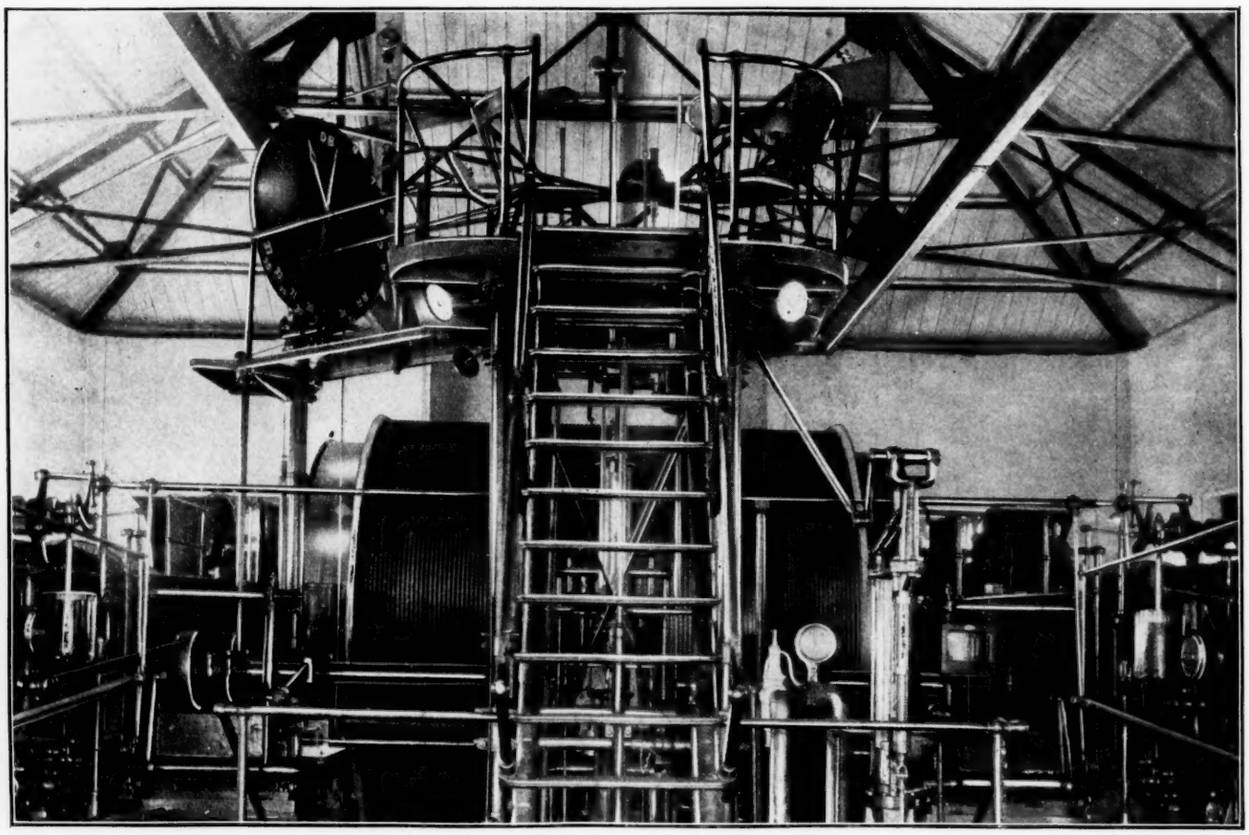


FIG. 1. CONTROL PLATFORM LOCATED OVER DRUM

The hoist is a horizontal, twin steam-cylinder engine. Both steam cylinders have Corliss valves and are next to the crossheads. The air-compressor cylinders are immediately back of the steam cylinders. Extension piston rods pass through the head end of the steam cylinders, to which the air pistons are attached, thus forming a combined hoisting engine and air compressor.

While lowering the skip, the piston in the steam cylinders runs free, the weight of the skip (1,400 lb.) and the cable being sufficient to rotate the hoisting drum and operate the compressor pistons. While hoisting, the air pistons run free. Full control of the hoist is afforded by means of suitable levers convenient for handling by the engineer, who operates from an elevated platform. As the skip descends the shaft, its speed is governed by the engineer, who controls the amount of air compressed, and he can govern the work performed in the air cylinders between the limits of no load and full cylinder capacity.

The air-compressing cylinders (Fig. 3) are each designed with four valves of the Corliss type. Both bottom valves admit free air to the cylinder; the two upper ones are for regulating the air capacity and are controlled by the engineer while lowering the skip. Both are fitted with releasing mechanism and dashpots. In the heads of the compressor cylinders are spring-loaded discharge valves through which the air is delivered under pressure. When the two upper valves are open, the passage from the cylinder is direct to the air-inlet pipes through a chamber on top of the cylinder, and no air can be compressed.

The operation of these valves is as follows: When the skip is being lowered and the air piston is moving toward the end of the cylinder, if the regulating or top valve is open, the air in front of the piston will be forced back into the inlet pipe. Should the engineer trip the

valve at any point of the skip travel in the shaft, the dashpot will close and the air left in the cylinder will begin to compress until a pressure is reached sufficient to open the discharge valve, when it passes to the storage tanks.

The farther the engineer moves his lever the more air will be compressed and the resistance on the air pistons will be increased. In this way the air cylinders regulate the speed of the hoist while lowering the skip. Ordinary steam-operated brakes are used for controlling the speed for the landing of the skip. On the steam cylinders the exhaust valves are arranged to be released from their connections and remain wide open and stationary so as to enable the engine to run free while lowering the skip. Upon reversing the direction of rotation for hoisting, they are hooked up again. This releasing and hooking-up mechanism is operated by a small steam-thrust cylinder. As the operating gears of the cylinders are connected to the reversing gear of the hoisting engine, the exhaust valves are either released or hooked up as the case may be, when the engineer reverses the engine, without any other attention on his part.

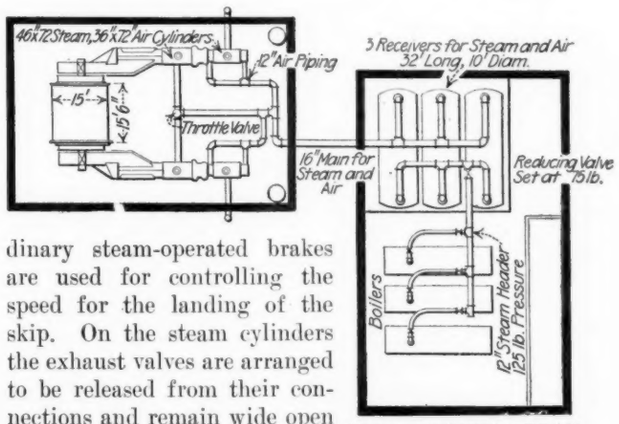


FIG. 2. GENERAL PLAN

All air compressed by the machine is mixed with the steam from the boilers, and the mixture is used in the steam cylinders of the hoist during the hoisting period. The mixture takes place in three cylindrical drums, each 10 ft. in diameter and 32 ft. long. As shown in the plan view (Fig. 2), a 12-in. steam pipe runs from the three 200-hp. locomotive-type boilers to one end of the receivers. From the opposite end of the receivers a 16-in. pipe is run to the throttle valve of the engine. There is also a 12-in. discharge pipe from each air compressor, which connects with the 16-in. line that carries the air to the receivers while lowering the skip and air and steam to the steam cylinders while hoisting. In the 12-in. pipe between the boilers (which carry 125-lb. pressure) and the receiver tanks, there is a reducing valve set to maintain about 65 lb. pressure on the receivers.

The operation of the receivers, tank and reducing valve is such that when the skip is at the top the receivers are under a steam pressure of, say, 65 lb., and when it is lowered into the mine the air compressors begin to discharge compressed air in to the receivers, where the air is mixed with the steam which they already contain. This pressure increases until by the time the skip reaches the bottom of the mine it is 95 lb. in the receivers. When starting to hoist, the pressure gradually decreases until 65 lb. is reached as the engine uses up the stored air produced by the lowering of the skip. When this pressure is reached in the receivers, the reducing valve opens and steam from the boilers goes to the engine to complete the remainder of the hoisting travel. When the hoist stops, the pressure in the tank is built up to 65 lb., and upon the next lowering of the skip the operation is repeated. The skip is hoisted about 1,000 ft. with air pressure and the remaining distance with steam.

The general dimensions of the hoist are as follows:

Diameter of steam cylinders	46 in.
Diameter of air cylinders	36 in.
Stroke of all cylinders	72 in.
Diameter of piston rods	7½ in.
Diameter of hoisting drum	15 ft.
Length of hoisting drum	15 ft. 5 in.
Capacity of drum, rope	5,130 ft. 1⅝ in.
Weight of skip	14,000 lb.
Weight of rock	20,000 lb.
Approximate velocity of skip hoisting	1,500 ft. per min.
Approximate velocity of skip lowering	2,000 ft per min.
Shaft dip	47 deg. from horizontal

Only three levers are required to handle this hoist—a throttle, a reversing and a brake lever, the same as on other types of hoists. In this instance, however, the throttle lever usually stands in a vertical position when the hoist is stopped. If the engineer pushes it from him, it operates the throttle valve; if he pulls it toward him, it acts on the regulating valves of the air cylinders.

The idea of using this type of hoisting engine originated with R. M. Edwards, general manager of the Franklin Mining Co., of the Lake Superior copper district, and it was built by the Nordberg Mfg. Co.

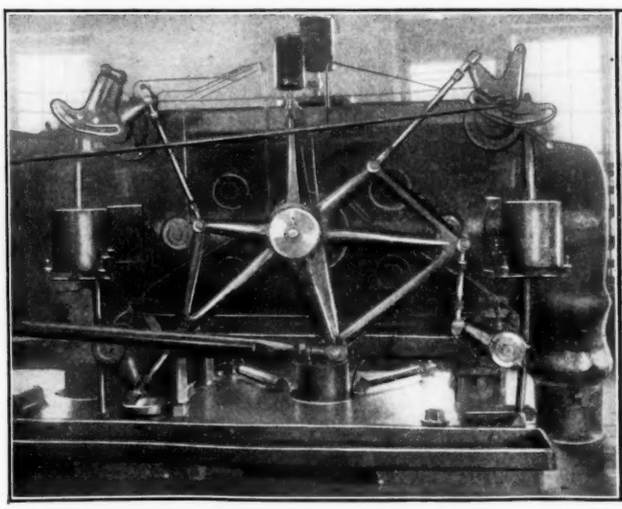


FIG. 3. VALVE GEAR OF COMPRESSOR CYLINDER

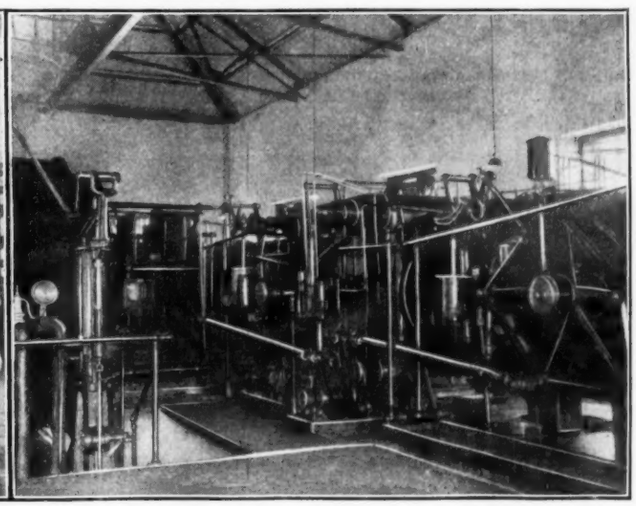


FIG. 4. ENGINE, LOOKING TOWARD STEAM END

Steam Needed by Perfect Engine

The body of the table gives the number of pounds of steam that would be required by an engine or turbine of 100 per cent. efficiency, working with adiabatic expansion from the chosen initial conditions of pressure and superheat, to atmospheric (212-deg.) exhaust pressure.

Initial Pressure, Lb. per Sq.In. Absolute	Initial Superheat, Degrees Fahrenheit																				
	00	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
101	18.11	17.98	17.88	17.77	17.65	17.51	17.37	17.24	17.11	16.98	16.84	16.70	16.56	16.43	16.28	16.15	15.99	15.85	15.70	15.54	15.40
102	18.01	17.91	17.79	17.67	17.55	17.43	17.30	17.17	17.03	16.90	16.76	16.62	16.49	16.35	16.21	16.05	15.90	15.77	15.63	15.47	15.33
103	17.92	17.82	17.71	17.59	17.45	17.32	17.19	17.07	16.94	16.82	16.68	16.53	16.40	16.26	16.13	15.98	15.83	15.70	15.54	15.40	15.26
104	17.83	17.73	17.61	17.50	17.38	17.24	17.12	16.99	16.85	16.73	16.60	16.45	16.32	16.19	16.04	15.91	15.77	15.62	15.48	15.32	15.18
105	17.75	17.63	17.53	17.41	17.29	17.16	17.02	16.90	16.77	16.64	16.51	16.39	16.25	16.12	15.97	15.83	15.69	15.54	15.40	15.26	15.12
106	17.66	17.55	17.43	17.32	17.19	17.07	16.95	16.83	16.70	16.57	16.44	16.29	16.17	16.03	15.89	15.77	15.62	15.47	15.34	15.18	15.04
107	17.59	17.48	17.37	17.26	17.14	17.01	16.87	16.74	16.61	16.49	16.36	16.22	16.10	15.96	15.82	15.69	15.54	15.43	15.27	15.13	14.98
108	17.50	17.39	17.29	17.17	17.04	16.92	16.80	16.66	16.53	16.42	16.28	16.16	16.02	15.89	15.76	15.62	15.47	15.33	15.20	15.05	14.91
109	17.42	17.31	17.21	17.09	16.96	16.84	16.73	16.60	16.47	16.34	16.21	16.07	15 95	15.82	15.69	15.55	15.41	15.27	15.14	14.99	14.85
110	17.35	17.23	17.12	17.01	16.89	16.76	16.64	16.51	16.40	16.26	16.14	16.00	15.87	15.75	15.62	15.48	15.34	15.20	15.07	14.92	14.78
111	17.26	17.15	17.04	16.93	16.82	16.70	16.58	16.45	16.32	16.20	16.06	15.94	15.82	15.69	15.55	15.41	15.27	15.14	15.00	14.85	14.72
112	17.18	17.09	16.99	16.85	16.74	16.62	16.50	16.36	16.25	16.12	15.99	15.86	15.75	15.61	15.48	15.35	15.22	15.07	14.94	14.80	14.66
113	17.11	17.01	16.90	16.79	16.68	16.56	16.43	16.30	16.19	16.06	15.94	15.81	15.69	15.55	15.41	15.28	15.15	15.01	14.88	14.74	14.60
114	17.04	16.94	16.84	16.73	16.61	16.48	16.36	16.24	16.12	15.99	15.86	15.74	15.61	15.49	15.36	15.22	15.08	14.94	14.82	14.68	14.54
115	17.09	16.86	16.76	16.65	16.55	16.42	16.29	16.17	16.04	15.93	15.80	15.68	15.54	15.42	15.30	15.16	15.03	14.89	14.76	14.62	14.49
116	16.90	16.80	16.69	16.58	16.47	16.34	16.22	16.10	15.98	15.86	15.74	15.61	15.49	15.37	15.24	15.10	14.97	14.83	14.70	14.57	14.43
117	16.84	16.73	16.62	16.50	16.40	16.27	16.16	16.03	15.91	15.81	15.68	15.54	15.42	15.30	15.17	15.05	14.92	14.78	14.64	14.50	14.37
118	16.77	16.66	16.56	16.45	16.33	16.21	16.10	15.97	15.84	15.74	15.61	15.49	15.37	15.24	15.11	14.98	14.85	14.72	14.58	14.45	14.31
119	16.71	16.61	16.49	16.37	16.27	16.15	16.03	15.91	15.80	15.69	15.55	15.43	15.31	15.18	15.06	14.92	14.79	14.67	14.53	14.39	14.26
120	16.63	16.53	16.43	16.32	16.21	16.09	15.96	15.84	15.73	15.62	15.50	15.37	15.25	15.12	14.99	14.86	14.73	14.62	14.47	14.34	14.22
121	16.58	16.47	16.35	16.25	16.15	16.02	15.90	15.79	15.66	15.55	15.43	15.31	15.19	15.07	14.94	14.81	14.68	14.57	14.43	14.29	14.15
122	16.51	16.41	16.30	16.19	16.07	15.95	15.84	15.73	15.60	15.50	15.37	15.25	15.13	15.00	14.88	14.75	14.62	14.51	14.37	14.23	14 10
123	16.45	16.34	16.24	16.13	16.02	15.90	15.79	15.67	15.55	15.44	15.31	15.20	15.08	14.95	14.83	14.70	14.57	14.45	14.31	14.18	14.05
124	16.39	16.28	16.18	16.06	15.95	15.83	15.72	15.61	15.50	15.38	15.26	15.14	15.02	14.90	14.77	14.64	14.52	14.38	14.26	14.13	14.00
125	16.31	16.22	16.11	15.99	15.88	15.77	15.66	15.54	15.42	15.31	15.20	15.07	14.95	14.83	14.71	14.58	14.46	14.34	14.21	14.08	13.95
126	16.26	16.16	16.04	15.94	15.83	15.71	15.60	15.49	15.38	15.26	15.14	15.02	14.89	14.77	14.65	14.52	14.40	14.28	14.15	14.03	13.90
127	16.20	16.10	15.98	15.87	15.77	15.66	15.54	15.43	15.32	15.20	15.07	14.96	14.84	14.72	14.60	14.47	14.35	14.23	14.11	13.97	13.84
128	16.14	16.03	15.92	15.82	15.72	15.60	15.48	15.38	15.26	15.15	15.02	14.91	14.79	14.67	14.55	14.43	14.30	14.18	14.06	13.93	13.80
129	16.07	15.98	15.87	15.78	15.67	15.55	15.43	15.32	15.21	15.10	14.98	14.85	14.73	14.62	14.49	14.38	14.26	14.13	14.01	13.88	13.76
130	16.02	15.92	15.82	15.72	15.61	15.49	15.38	15.27	15.16	15.05	14.92	14.80	14.68	14.57	14.45	14.33	14.21	14.08	13.97	13.84	13.72
131	15.97	15.87	15.76	15.66	15.55	15.44	15.34	15.22	15.10	14.99	14.87	14.75	14.63	14.52	14.40	14.28	14.16	14.04	13.92	13.79	13.67
132	15.92	15.82	15.71	15.61	15.51	15.38	15.27	15.16	15.05	14.93	14.82	14.71	14.59	14.47	14.35	14.23	14.11	13.99	13.87	13 75	13 63
133	15.87	15.77	15.66	15.55	15.45	15.35	15.23	15.11	14.99	14.89	14.77	14.66	14.55	14.43	14.31	14.19	14.07	13.95	13.82	13.70	13.59
134	15.82	15.72	15.61	15.50	15.38	15.28	15.17	15.06	14.94	14.84	14.72	14.61	14.50	14.38	14.26	14.14	14.03	13.91	13.78	13.66	13.54
135	15.77	15.67	15.56	15.45	15.34	15.23	15.11	15.00	14.90	14.79	14.68	14.57	14.45	14.33	14.22	14.10	13.98	13.86	13.74	13.62	13.56
136	15.72	15.61	15.51	15.39	15.29	15.18	15.07	14.97	14.85	14.74	14.62	14.52	14.40	14.29	14.17	14.05	13.93	13.81	13.70	13.57	13.46
137	15.67	15.56	15.46	15.35	15.24	15.13	15.03	14.92	14.80	14.69	14.57	14.47	14.35	14.24	14.12	14.00	13.89	13.77	13.65	13.53	13.41
138	15.61	15.51	15.40	15.30	15.19	15.07	14.98	14.86	14.76	14.65	14.53	14.43	14.31	14.19	14.07	13.96	13.84	13.73	13.61	13.49	13.37
139	15.56	15.46	15.36	15.25	15.15	15.03	14.92	14.80	14.70	14.60	14.48	14.37	14.26	14.14	14.03	13.91	13.80	13.68	13.56	13.45	13.33
140	15.52	15.41	15.30	15.20	15.09	14.99	14.88	14.77	14.67	14.55	14.43	14.32	14.21	14.10	13.99	13.87	13.75	13.64	13.52	13.41	13.29
141	15.47	15.37	15.26	15.16	15.05	14.94	14.83	14.72	14.62	14.51	14.39	14.27	14.16	14.05	13.94	13.83	13.71	13 59	13.48	13.36	13.25
142	15.41	15.31	15.20	15.10	14.99	14.89	14.78	14.68	14.57	14.46	14.34	14.23	14.12	14.00	13.90	13.79	13.67	13.55	13.44	13.32	13.21
143	15.37	15.27	15.16	15.06	14.95	14.85	14.74	14.64	14.53	14.42	14.30	14.20	14.09	13.97	13.86	13.75	13.64	13.52	13.41	13.29	13.18
144	15.32	15.23	15.13	15.02	14.92	14.80	14.70	14.59	14.48	14.37	14.26	14.15	14.04	13.93	13.81	13.70	13.59	13.49	13.36	13.25	13.14
145	15.28	15.17	15.07	14.98	14.87	14.76	14.65	14.55	14.43	14.33	14.23	14.11	14.00	13.89	13.78	13.67	13.56	13.44	13.33	13.21	13.10
146	15.24	15.14	15.03	14.92	14.83	14.72	14.61	14.51	14.40	14.29	14.18	14.07	13.95	13.84	13.74	13.63	13.51	13.40	13.29	13.18	13.06
147	15.19	15.09	14.99	14.88	14.79	14.68	14.57	14.46	14.36	14.25	14.14	14.04	13.92	13.81	13.70	13.59	13.48	13.36	13.25	13.14	13.03
148	15.14	15.04	14.94	14.84	14.73	14.62	14.52	14.42	14.31	14.21	14.10	13.99	13.88	13.77	13.66	13.55	13.44	13.32	13.21	13.10	12.99
149	15.10	15.01	14.90	14.79	14.69	14.58	14.47	14.38	14.27	14.17	14.06	13.95	13.84	13.73	13.62	13.51	13.39	13.28	13.17	13.06	12.96
150	15.07	14.97	14.85	14.75	14.66	14.54	14.44	14.34	14.23	14.14	14.03	13.92	13.81	13.70	13.59	13.48	13.36	13.25	13.14	13.04	12.92
151	15.02	14.92	14.82	14.72	14.61	14.50	14.39	14.29	14.19	14.09	13.98	13.87	13.76	13.65	13.55	13.44	13.32	13.21	13.10	13 00	12.88
152	14.98	14.87	14.77	14.67	14.57	14.46	14.35	14.26	14.14	14.04	13.94	13.82	13.72	13.62	13.51	13.40	13.28	13.18	13.06	12.96	12.85
153	14.93	14.83	14.73	14.62	14.52	14.43	14.32	14.22	14.11	14.00	13.90	13.80	13.69	13.58	13.47	13.36	13.25	13.14	13.03	12.92	12.81
154	14.90	14.79	14.69	14.58	14.48	14.38	14.28	14.18	14.08	13.97	13.87	13.75	13.65	13.54	13.44	13.32	13.22	13.11	13.00	12.89	12.78
155	14.85	14.76	14.65	14.55	14.46	14.36	14.24	14.14	14.04	13.94	13.82	13.72	13.61	13.51	13.39	13.29	13.18	13.08	12.96	12.85	12.75
156	14.81	14.71	14.61	14.51	14.41	14.30	14.20	14.11	14.00	13.90	13.78	13.68	13.57	13.47	13.34	13.25	13.14	13.04	12.92	12.83	12.72
157	14.77	14.68	14.57	14.47	14.37	14.26	14.16	14.06	13.96	13.85	13.75	13.64	13.54	13.43	13.32	13.22	13.11	13.00	12.89	12.79	12.69
158	14.73	14.63	14.52	14.43	14.33	14.22	14.12	14.02	13.92	13.82	13.72	13.61	13.51	13.89	13.29	13.18	13.07	12.96	12.86	12.76	12.65
159	14.69	14.60	14.49	14.40	14.30	14.19	14.10	13.98	13.89	13.78	13.68	13.58	13.47	13.36	13.25	13.15	13.04	12.94	12.83	12.72	12.62
160	14.66	14.57	14.46	14.36	14.26	14.15	14.05	13.95	13.84	13.74	13.64	13.54	13.44	13.33	13.22	13.12	13.02	12.90	12.80	12.69	12.59
161	14.62	14.52	14.43	14.32	14.22	14.12	14.02	13.91	13.82	13.72	13.60	13.50	13.40	13.29	13.19	13.09	12.98	12.87	12.76	12.66	12.56
162	14.58	14.48	14.38	14.29	14.19	14.08	13.98	13.87	13.78	13.67	13.58	13.47	13.36	13.26	13.16	13.06	12.94	12.83	12.73	12.63	12.53
163	14.55	14.45	14.34	14.25	14.15	14.04	13.95	13.85	13.75	13.64	13.54	13.44	13.34	13.23	13.12	13.02	12.91	12.81	12.70	12.60	12.49
164	14.52	14.42	14.32	14.22	14.12	14.01	13.91	13.82	13.72	13.62	13.51	13.41	13.30	13.20	13.10	13.00	12.89	12.78	12.68	12.57	12.47
165	14.48	14.38	14.28	14.18	14.08	13.97	13.88	13.78	13.69	13.58	13.48	13.38	13.27	13.17	13.07	12.96	12.85	12.75	12.65	12.54	12.44
166	14.45	14.35	14.25	14.14	14.05	13.95	13.84	13.75	13.64	13.54	13.45	13.34	13.24	13.13	13.03	12.92	12.82	12.72	12.62	12.52	12.41
167	14.41	14.32	14.21	14.11	14.02	13.91	13.81	13.71	13.62	13.51	13.41	13 31	13.21	13.10	13.00	12.90	12.79	12.69	12.58	12.48	12.38
168	14.38	14.28	14.18	14.08	13.97	13.88	13.78	13.67	13.58	13.48	13.38	13.27	13.20	13.08	12.97	12.86	12.76	12.66	12.55	12.45	12.35
169	14.34	14.25	14.14	14.04	13.95	13.84	13.75	13.64	13.55	13.45	13.34	13.25	13.14	13.04	12.94	12.83	12.74	12.63	12.53	12.43	12.32
170	14.31	14.21	14.11	14.01	13.91	13.81	13.70	13.60	13.51	13.41	13.32	13.21	13.12	13.01	12.90	12.80	12.70	12.60	12.49	12.39	12.29
171	14.29	14.18	14.08	13.98	13.88	13.78	13.68	13.58	13.49	13.39	13.28	13.18	13.08	12.98	12.87	12.77	12.67	12.57	12.47	12.37	12.28
172	14.25	14.14	14.04	13.95	13.84	13.75	13.64	13.55	13.45	13.35	13.25	13.15	13.06	12.95	12.85	12.74	12.64	12.54	12.44	12.33	12.24
173	14.22	14.11	14.01	13.91	13.82	13.71	13.62	13.51	13.42	13.32	13.22	13.12	13.02	12.92	12.81	12.72	12.62	12.51	12.41	12.31	12.21
174	14.18	14.07	13.97	13.87	13.78	13.69	13.59	13.49	13.38	13.28	13.19	13.09	12.99	12.88	12.79	12.69	12.58	12.49	12.38	12.28	12.19
175	14.15	14.05	13.95	13.85	13.75	13 65	13.55	13.46	13.36	13.26	13.16	13.06	12.96	12.86	12.76	12.66	12.56	12.46	12.36	12.26	12.16
176	14.11	14.01	13.91	13.82	13.72	13.62	13.52	13.42	13.32	13.23	13.13	13.03	12.94	12.83	12.73	12.63	12.53	12.43	12.33	12.23	12.13
177	14.08	13.98	13.88	13.78	13.68	13.59	13.49	13.39	13.29	13.20	13.10	13.00	12.90	12 80	12.70	12.60	12.50	12.39	12.30	12.22	12 11
178	14.05	13.95	13.84	13.75	13.65	13.55	13.46	13.36	13.26	13.16	13.07	12.97	12.87	12.77	12.67	12.57	12.47	12.37	12.28	12.18	12.08
179	14.01	13.91	13.81	13.72	13.62	13.52	13.42	13.33	13.23	13.14	13.04	12.94	12.84	12 74	12.64	12.55	12.44	12.34	12.24	12.15	12 05
180	13.99	13.89	13.78	13.69	13.59	13.50	13.40	13.29	13.21	13.10	13.01	12.91	12.81	12.72	12.62	12.52	12.42	12.32	12.22	12.12	12.03
181	13.96	13.87	13.75	13.67	13.56	13.46	13.37	13.27	13.18	13.08	12.98	12.88	12.79	12.69	12.58	12.49	12.39	12.29	12.19	12.10	12.00
182	13.93	13.83	13.73	13.63	13.54	13.44	13.34	13.25	13.15	13.06	12.96	12.86	12.76	12.67	12.57	12.46	12.36	12.27	12.17	12.07	11 97
183	13.90	13.81	13.70	13.60	13.51	13.41	13.31	13.21	13.12	13.02	12.92	12.83	12.73	12.63	12.54	12.44	12.33	12.24	12.15	12.05	11.95
184	13.87	13.77	13.67	13.57	13.47	13.38	13.28	13.18	13.09	13 00	12.90	12 80	12.70	12 61	12.51	12.41	12.31	12.22	12 12	12.02	11.93
185	13.84	13.74	13.63	13.54	13.44	13.34	13.25	13.16	13.06	12.97	12.86	12 77	12.68	12.57	12.47	12.38	12.28	12 19	12.09	12.00	11.90
186	13.81	13 71	13.61	13.51	13 42	13.32	13.23	13 13	13.04	12 91	12 81	12 74	12.65	12.55	12.46	12.36	12.26	12.16	12.07	11 97	11.88
187	13.78	13.68	13.57	13.48	13 39	13.29	13.19	13 10	13.01	12 91	12.81	12.72	12 62	12 53	12.43	12.33	12.23	12 13	12.04	11 95	11.86
188	13 75	13 65	13.55	13.46	13 36	13.26	13.16	13.07	12.98	12 88	12.78	12 69	12 60	12 50	12.40	12.30	12 21	12 11	12 01	11.92	11.83
189	13.72	13 62	13 52	13.43	13 33	13.24	13.14	13.04	12.95	12 85	12.76	12 66	12 57	12 47	12 38	12.28	12 18	12.09	11.99	11.90	11.81
190	13.69	13 60	13.49	13.40	13.31	13.21	13.10	13.01	12.92	12 83	12.73	12.63	12.54	12 45	12.35	12.26	12 16	12.06	11.96	11.87	11.78
191	13.67	13 57	13.46	13.38	13 28	13.18	13.08	12.99	12.90	12 81	12 71	12 62	12 52	12 43	12 33	12.23	12 14	12.04	11 95	11.85	11.76
192	13.64	13 54	13.44	13.34	13.25	13.16	13 06	12.96	12 87	12 78	12 69	12 59	12 50	12 39	12 30	12.21	12 11	12.01	11.92	11.83	11.74
193	13 62	13 51	13.41	13.32	13.22	13 13	13 03	12 93	12 84	12 75	12 66	12 57	12 47	12 37	12 28	12 18	12 09	11.99	11.90	11.80	11.72
194	13.59	13.49	13.38	13.29	13.20	13 10	13 00	12 91	12 82	12 73	12 63	12 54	12 44	12 35	12 26	12 16	12 07	11 97	11 87	11 78	11.69
195	13.56	13.46	13.35	13.26	13.17	13.07	12.98	12.88	12.79	12.70	12.60	12.51	12.42	12 32	12 23	12 13	12 03	11.94	11 85	11.76	11.67
196	13.53	13.43	13.32	13.23	13.14	13 05	12 95	12 85	12 76	12 67	12 58	12 49	12 39	12 30	12 20	12 11	12 01	11 92	11 82	11.73	11 65
197	13.51	13.41	13.30	13.21	13.12	13 02	12 92	12 83	12 74	12 65	12 55	12 46	12 37	12 28	12 18	12 09	11.99	11 90	11 80	11.71	11 62
198	13.49	13 39	13.28	13.19	13 10	13 00	12 90	12 81	12 72	12 63	12.54	12 44	12 35	12 25	12 16	12 07	11 97	11 88	11 79	11 69	11 61
199	13.46	13.36	13.25	13.16	13.07	12 97	12 88	12.79	12 70	12 60	12.51	12.42	12 33	12 23	12 14	12.05	11.95	11 86	11.76	11.67	11 59
200	13.43	13.33	13.23	13.14	13.04	12.95	12.85	12.76	12.67	12.58	12.48	12.39	12.30	12 21	12 12	12 03	11.93	11.83	11.74	11.65	11.56

Steam Needed by Perfect Engine

By F. R. Low

The table on the opposite page gives the number of pounds of steam that would be required per indicated horsepower-hour by an engine of 100 per cent. efficiency expanding steam adiabatically from various initial conditions of pressure and superheat and exhausting at 212 deg. F. without compression. This is what is commonly understood by the Rankine cycle, and the ratio of the theoretical steam rate under these conditions to the actual steam rate as the Rankine efficiency or Rankine efficiency ratio.

As an example of the use of the table, an ideally perfect engine working with steam of 150 lb. gage (say 165 lb. absolute) initial pressure and 100 deg. superheat exhausting at 212 deg. would require 13.48 lb. of steam per indicated horsepower-hour. A guarantee of 18 lb. is within reason, for this is 13.48 ÷ 18 = 74.9 per cent. of the possible and there is over 25 per cent. allowance for losses.

Or again, a builder knows from tests and experience that he can get an over-all efficiency of 80 per cent. with his engine running noncondensing. What guarantee could he afford to make on the steam rate if given an initial pressure of 140 lb. absolute and not less than 90 deg. superheat?

The theoretical steam rate for the given conditions is, from the table, 14.55 lb. If this is 80 per cent. of the allowable consumption, 100 per cent., or the whole, of the latter will be 14.55 ÷ 0.80 = 18.2, nearly.

Over-All Efficiency Considered

When the guarantee is given in pounds of steam per kilowatt-hour, the over-all efficiency of the unit must be taken into consideration. A well-known engine builder recently offered to produce a kilowatt-hour on 22 lb. of steam under the assumed conditions, 150 lb., 100 deg. and atmospheric exhaust. His method of figuring it is obvious. He felt that he could get 80 per cent. efficiency with his engine, which would make its steam rate 13.48 ÷ 0.80 = 16.75 lb. per i.hp.-hr. Using the common assumption that a kilowatt = 1⅓ hp., he figured that the consumption per kilowatt would be 1⅓ times that per horsepower, or 16.75 × 1⅓ = 22.3 lb., and that 22 lb. would be perfectly safe. But an engine and generator will not turn out a kilowatt for every 1⅓ hp. generated in its cylinder. Some of this indicated horsepower goes to overcome engine and generator friction, flywheel and armature windage and electrical losses; so that in a unit of the size under consideration, 250 kw., an over-all efficiency of not more than 82 per cent. would be safe to assume.

Therefore, this would mean that to make a kilowatt would require $\frac{1,000}{746 \times 0.82} = 1.63$ i.hp., which at the ideal consumption would require 13.48 × 1.63 = 21.97 lb., so that at 22 lb. he was guaranteeing a performance of practically 100 per cent.

The table is made by computing first the number of B.t.u. that would be converted into work by a 100 per cent. engine out of each pound of steam expanded from the given initial state to 212 deg. One horsepower-hour is equivalent to 1,980,000 ft.-lb. and one B.t.u. = 777.536 ft.-lb., so that a horsepower-hour is equivalent to $\frac{1,980,000}{778} = 2,545$ B.t.u.[1] per hour. Dividing this by the number of B.t.u. theoretically contributed by each pound of steam gives the number of pounds of steam theoretically required. The number of B.t.u. thus converted per pound of steam is found by the following formula (not applicable when the expansion is such that the exhaust is superheated, a condition outside of the range of the table):

$$U = H_1 - h_2 - (N_1 - n_2)T_2$$

where

U = Heat converted per pound;
H_1 = Total heat per pound, initial condition;
h_2 = Heat of liquid in final condition;
N_1 = Total entropy in initial condition;
n_2 = Entropy of liquid in final condition;
T_2 = Absolute temperature in final condition.

All these values are obtainable from the tables of the physical properties of steam, the Marks-Davis table being used in this case.

The use of the table will perhaps be illustrated best by the working out of an actual example, hence the following:

How many pounds of steam of 160-lb. absolute pressure and 90 deg. superheat would be required per horsepower-hour by a perfect engine, the steam to be worked adiabatically from the given initial condition to atmospheric pressure, 212 deg.?

$$\begin{array}{rrrr} & & & 1,246.1 = H_1 \\ N_1 = 1.6235 & & 212.0 & 180.0 = h_2 \\ n_2 = 0.3118 & & 459.6 & 1,066.1 = H_1 - h_2 \\ (N_1 - n_2) = 1.3117 & \times & 671.6 = & 880.9 = (N_1 - n_2)T_2 \\ & & & U = 185.2 \end{array}$$

$$\text{or, } \frac{2,544.65}{185.2} = 13.75 \text{ lb. per hp.-hr.}$$

Don't Miss This One

The *Glasgow Herald* recently published the following advertisement:

Wanted (duration of war), experienced man thorough knowledge of gas engine and steam boiler, able to attend and repair, also to look after horses; must have good connection as salesman and experience as carter; able to lift 2-cwt. bags; willing to feed horses during week-end; 45s. [$10.95] to suitable man; must have good references and character; ineligible for Army; see War Notice.—7,104, Herald Office.

We are glad to give publicity to this particular advertisement, because it is doubtful if there are many individuals who can boast of so many accomplishments, and it may be necessary to run the advertisement a second time. In order to land the position, the applicant must be a second edition of James Watt, a judge of horse flesh, have experience behind the counter, know how to cluck at a horse, have the strength of a Sandow, and—and live largely on faith.

A Liquid Escaping through a sharp-edged orifice instead of assuming a cylindrical form, at first contracts and takes the form of a truncated cone. It is found that the escaping jet continues to contract until at a distance from the orifice about equal to the diameter of the orifice. This part of the jet is called the vena contracta, and the area of this small section is about ⅝, or 0.625, of that of the orifice. Accordingly, the true value of the efflux per second is given approximately by the formula $E = 0.62\ A\sqrt{2gh}$, or the actual value of E is about 0.62 of its theoretical value.

[1] The table is made with Hering's value, 2,544.65. A later value from Marks-Davis Steam Tables would be 2,546.5. The use of this value would increase the figure in the second decimal place of the tabular values by about 1, making the value at the top of the first column 18.12 instead of 18.11

Practical Talks on Controllers--Time-Element Type*

SYNOPSIS—This article is the fourth of the series on controllers and describes the time-element type with sliding contacts. Its application, limitations, care and operation are explained. The butt-end contact time-element type was described in the Oct. 24 issue.

The sliding-contact type of self-starter in which a solenoid is utilized to operate the movable-contact member, as shown in Fig. 1, was one of the first to be used in the practical application of remote control of various kinds of electric-motor-driven machinery. Though not employed as indiscriminately as formerly, this form of starter, which is of the constant-time-element type, plays an important part in the electric-motor-control field today. The wide range of adjustment in accelerating time and the relatively large number of steps that are employed make the use of this type of starter particularly desirable where smooth acceleration or long periods of accelerating time are required. Its extensive use in connection with motor-driven fans, pumps and similar machinery brings it often into the hands of the plant-operating engineer or electrician, and on account of its simplicity of construction and operation, but little study is required to enable the one in charge to maintain an equipment of this nature in first-class running order.

The many forms of controlling devices on the market may be used with this type of starter. It is furnished with connections to operate with pressure regulators, float switches, manually operated snap switches, and manually operated push-buttons. Pressure regulators, when of the single-pole type, float switches and snap switches require two-wire control, while gage-type pressure regulators and push-buttons require three-wire control connections. The complete connections of this form of starter, together with a tank switch, are shown in Fig. 2; the circuits may be traced as follows:

Operation of the Controller

Closing the single-pole float-switch contacts connected by the two-wire circuit to terminals L and C completes the circuit from L_2 through the magnet coil M, operating the single-pole-magnetic line switch S, and the resistance between H and D to the contact segment upon which the rheostat lever rests in the off position. The rheostat lever being connected to L_1 the circuit through the magnet coil is completed to the negative side of the line, as indicated by the arrowheads, thus causing the coil M to be energized and the single-pole magnetic switch S to close, as shown in Fig. 3. Closure of this switch provides a connection from L_2 through the blowout coil O and the switch S to the common terminal of the motor A_2 (that terminal which connects to both one end of the shunt field and one armature brush), at which point it divides, one circuit going through the shunt-field winding to the F_1 terminal on the controller, then to L_1 and the negative side of the line, as indicated by the light arrowheads. The other circuit is through the armature to A_1 on the controller through the armature resistance R to L_1 on the controller and the negative side of the line. The completing of this circuit should cause the motor to start.

The closing of the magnet switch S also provides a circuit through an auxiliary contact F on the switch member to the rheostat-solenoid winding W, through the solenoid winding and the protecting switch P to L_1 and the negative side of the line. The completion of this circuit causes the solenoid to be energized, which in turn raises the rheostat lever. The initial movement upward of the rheostat lever causes it to break contact on the lower contact segment, necessitating that the magnet coil cur-

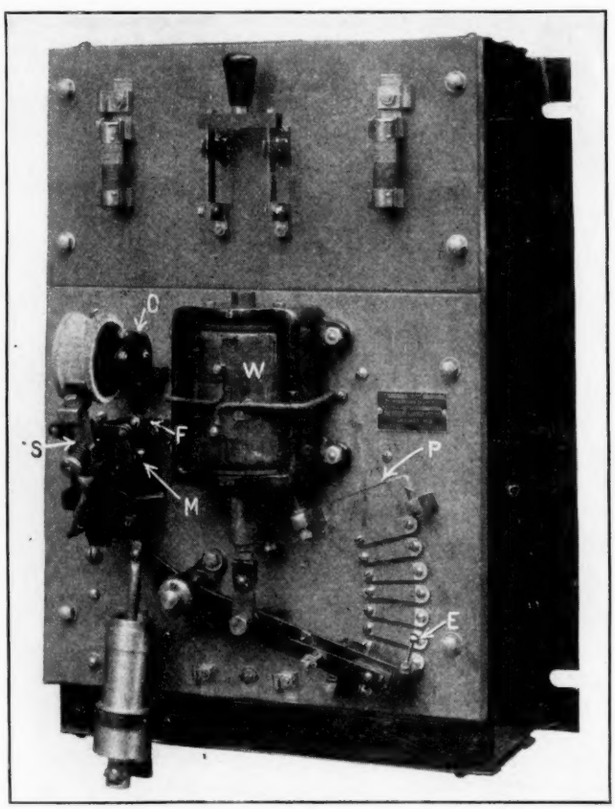


FIG. 1. CONSTANT-TIME-ELEMENT TYPE OF SELF-STARTER FOR DIRECT-CURRENT MOTORS

rent flow through the resistance between D and B to L_1 connection, as shown in Fig. 4. It will be seen, therefore, that the resistance between D and B is not inserted in the magnet coil circuit until after the switch S has closed and the rheostat arm has started on its upward travel. This resistance is of relatively high value and reduces materially the current that flows through the magnet coil M. As the armature member of the clapper switch is in the sealed position, the reduction in the current flowing in the coil does not in any way interfere with the operation of the switch, but less heating of the coil is obtained than if carrying the full current continuously. As the rheostat arm approaches the full-speed position shown in Fig. 5 and the solenoid plunger comes into the sealed position,

*The material in this article was contributed by T. D. Montgomery, of the Cutler-Hammer Manufacturing Co.

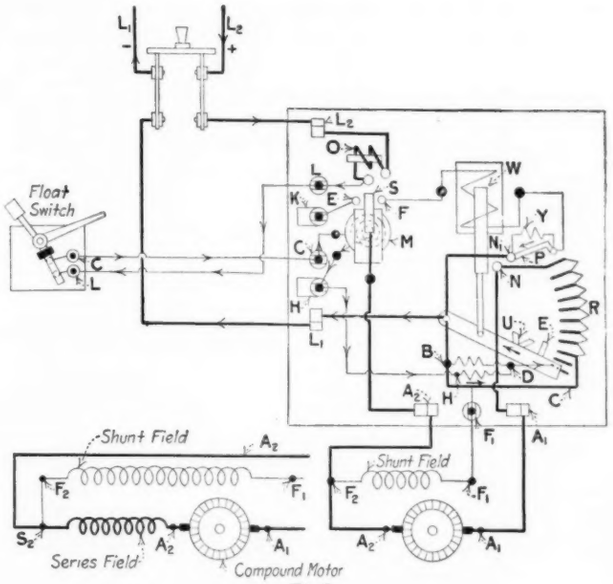


Fig.2

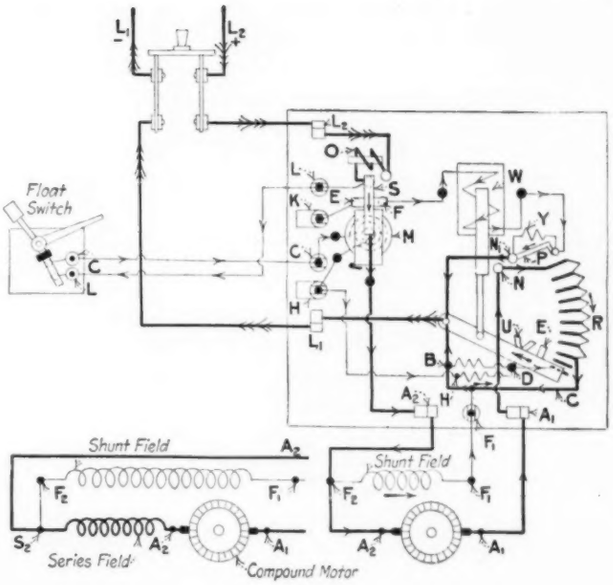


Fig.3

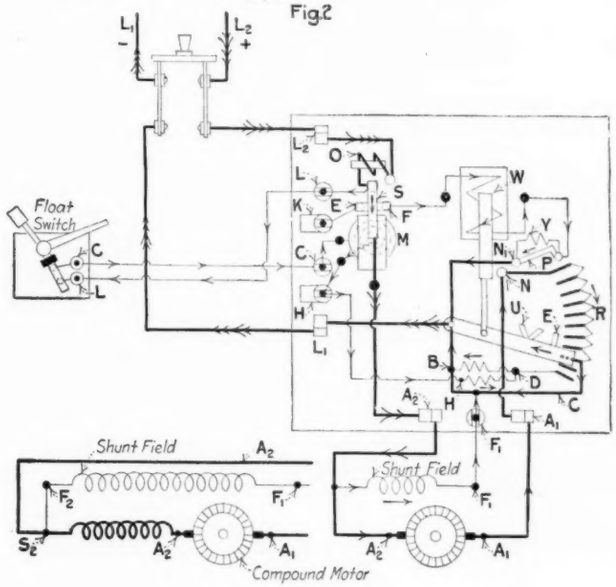


Fig.4

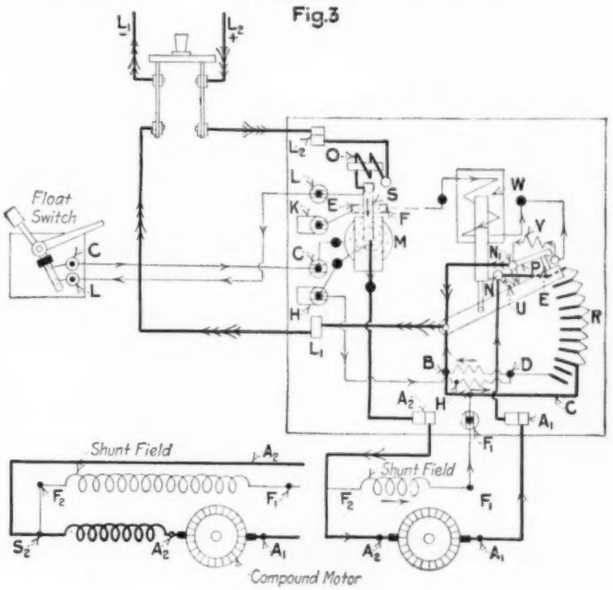


Fig.5

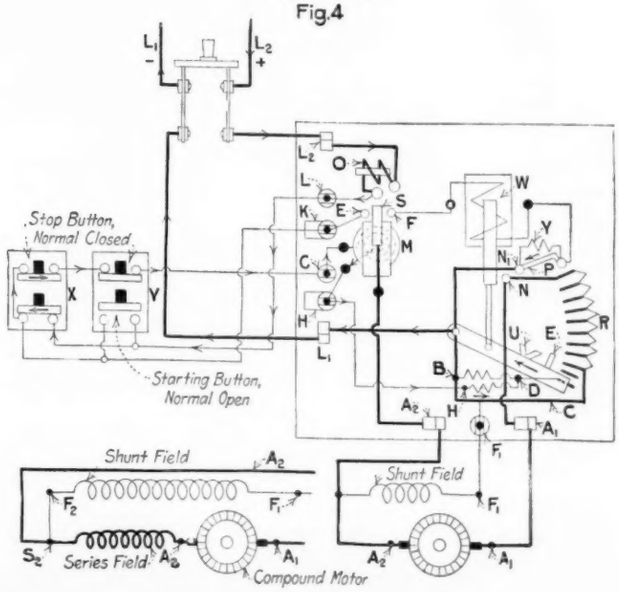


Fig6

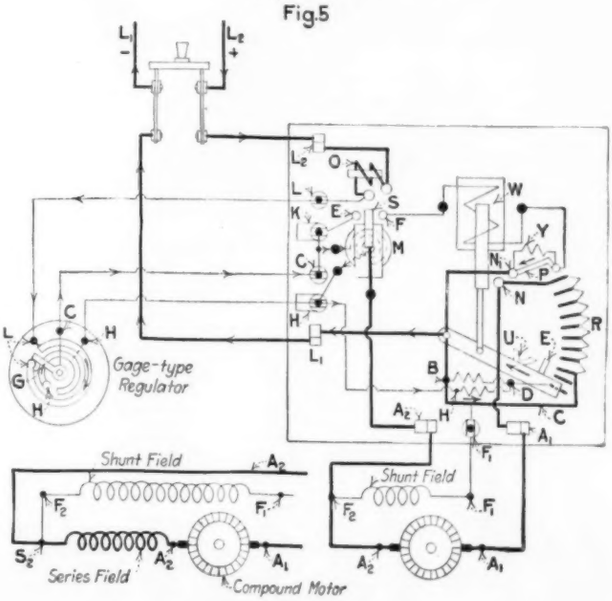


Fig.7

FIGS. 2 TO 7. DIAGRAMS OF CONNECTION FOR A CUTLER-HAMMER SLIDING-CONTACT TYPE SELF-STARTER

the protecting switch P directly above the rheostat contacts is opened by an adjustable screw E on the rheostat arm. The opening of this switch causes the insertion of a resistance Y in the solenoid circuit, thus reducing the current flowing through it and accomplishing the same result as described for the magnet coil.

It will be observed that a connection C is provided between the rheostat lever and the lower end of the resistance. This permits the rheostat arm leaving the resistance segments without breaking the armature circuit. The A_1 connection is taken to a contact N; the rheostat arm also connects to a contact N_1 against which a short-circuiting brush U on the rheostat arm bears in the full-running position so that the current, instead of passing through the rheostat lever, merely passes through the brush contact on the lever directly from A_1 to L_1, as indicated in Fig. 5. From the foregoing it can be seen that the rheostat-arm brushes do not carry the motor current except when the rheostat lever is in an intermediate position between all resistance in and all resistance out. The movement of the rheostat arm over the contact segments short-circuits the starting resistance step by step, until the rheostat arm is in the full-running position, at which time all the resistance is cut out and the motor armature is directly across the line. In the smaller-sized controllers, as shown in Fig. 1, only one brush is provided for short-circuiting the rheostat-arm contacts.

The Three-Wire Push-Button Control

The three-wire push-button control connections shown in Fig. 6 permit any number of push-buttons being connected in parallel and require an additional wire in the control circuit to that described in the foregoing. The figure shows two push-button stations X and Y. It will be noticed that the starting push-button is provided with normally opened contacts, as at Y, while the stopping button is normally closed. The extra circuit referred to is known as the maintaining circuit and is shown connected to terminal K, which connects to an auxiliary contact E on the clapper switch and has direct connection to L_2 when the clapper switch is closed, as in Figs. 3 to 5. Tracing the circuit with the starting button at X depressed, a continuous circuit is provided from L_2 through the normally closed stop-button to the magnet coil and back to L_1, as indicated by the arrowheads. The immediate result of the closure of this circuit is to cause the magnet coil to be energized and the switch S to be closed. The closure of this switch, in addition to providing the circuit for energizing the solenoid winding as described in Figs. 2 to 5, also completes the circuit to K in parallel with the circuit through the starting button so that when pressure is released on the starting button and its contacts opened, the circuit is maintained to the magnet coil through K. From this point the functioning is the same as described for the two-wire control. Pressure on the stopping buttons opens the contacts in the maintaining circuit, and the magnet coil is deënergized, thus releasing the switch member and causing the motor circuit to be opened.

By combining the two foregoing control circuits, it is possible to obtain with this form of starter operation by the Bourdon-tube type of pressure regulator, the contacts of which close the circuit between L and C to start the equipment, as shown in Fig. 7, thus energizing the magnet-switch coil in the same manner as previously described; the circuit is indicated by the arrowheads. After the magnet switch closes, the operating circuit is maintained by the circuit through K and the auxiliary-switch contact E. As the pressure increases, the arm G is caused to revolve around until it comes in contact with H. The closure of the circuit in the pressure regulator between C and H bridges the terminals of the magnet coil, thus allowing the current to pass directly from the L_2 connection through the resistance between H and B to L_1. The bypassing of the magnet coil causes it to be deënergized, with the consequent opening of the switch, the breaking of the maintaining circuit and the main motor circuit. As the pressure decreases, the arm G will swing back against the contact L and again start the motor.

Locating Trouble on the Controller

From an examination of the diagrams it will be seen that poor or improper contact between the rheostat-lever brush and the lower segment of the rheostat may prevent the clapper-switch coil from receiving sufficient current, thus causing it to fail to operate. Likewise, a poor contact on the auxiliary switch at F of the clapper-magnet switch will prevent the circuit being completed to the rheostat solenoid W upon the closing of this switch, while a poor contact on the protecting switch P above the rheostat contact will cause the resistance between A and B to be permanently in series with the rheostat-solenoid coil W, and it will not obtain sufficient current to cause it to operate in a normal manner.

An open circuit in the resistance between H and D will prevent the magnet switch S from closing upon the closing of the controlling device, while the opening of the resistance between D and B will cause the clapper switch to chatter or vibrate, for the reason that as soon as the rheostat arm leaves the lower segment, the circuit to the clapper-switch magnet coil is opened.

If the resistance Y is open the circuit to the solenoid coil W will still be compiete until the rheostat arm reaches the point where it opens the protecting switch P. When this occurs, the coil is deënergized and the rheostat arm drops down, thus closing the circuit again, and the operation is repeated. Care should be taken to see that the protecting switch P is not opened until the final movement of the solenoid plunger, as otherwise the protecting resistance may be cut in circuit before the arm is fully drawn up and the weakening of the solenoid will prevent it from pulling the arm into the final position. As the protecting resistance is depended upon to reduce the current in the coil and consequently the heating of the solenoid winding, it is extremely desirable that the switch be so adjusted that it always opens upon the final movement of the solenoid plunger.

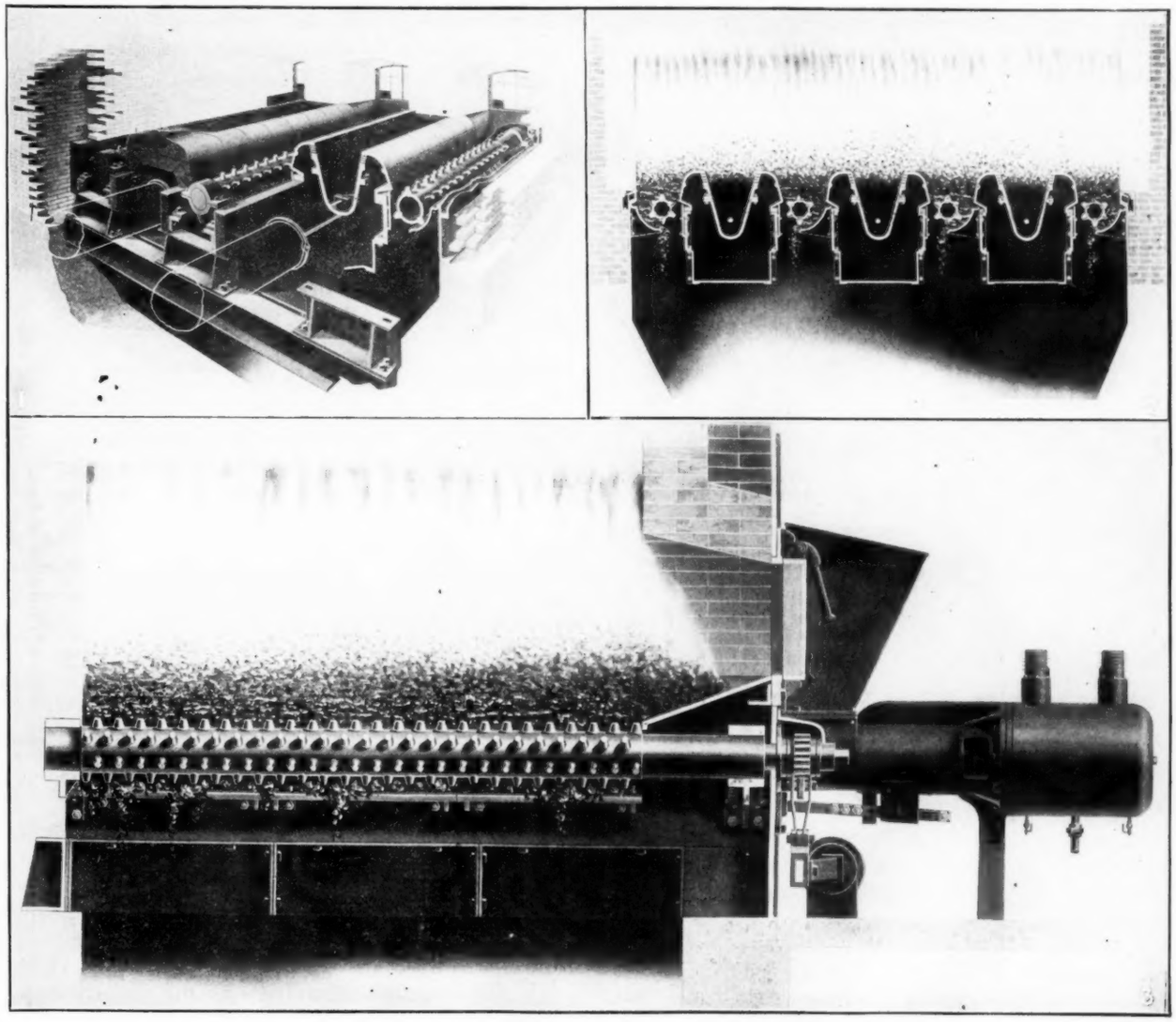
Upon the operation of the controlling device, the result is the closure of the single-pole magnetic switch. Should a resistance step become open-circuited, the motor will not receive current until the rheostat lever passes by the contact connected to the open section, the result being that the motor receives current with much less than the normal amount of resistance in circuit, thus causing excessive currents to flow with resulting burning and arcing on the contact segments. If the open-circuit point is well up on the rheostat, the reduction in the resistance value may be such as to allow a current to flow that will cause flashing on the commutator or the blowing of the fuses.

Moloch Underfeed Stoker

A self-cleaned stoker of the true underfeed type has been designed recently by the Moloch Stoker Co., of Chicago. Briefly, it consists of a retort running lengthwise of the furnace into which the fuel is pushed by a steam ram. Above the retorts are tuyeres to supply the air to the fuel bed, and on either side is a rotary grinder disposing of the refuse. The fresh fuel is fed underneath the zone of combustion, there being no moving or stationary grates to provide for overfeed burning. After being coked, every particle of fuel entering the furnace travels exactly the same distance on its way through the fire before giving up its noncombustible matter. In this way all fuel is allowed an equal opportunity to be completely consumed, and as the refuse does not interfere with the air supply or combustion, the ability of the underfeed principle to produce a high rate of smokeless operation is further assisted by a fire that is clean throughout the length of the furnace.

Fig. 1 is a perspective of a two-retort equipment, Fig. 2 is a vertical section through a furnace having three retorts, Fig. 3 is a longitudinal section through the furnace giving a side elevation of the refuse-disposal mechanism, and Fig. 4 is a section through the cylinder and ram. As will be apparent, the retorts are inclosed by cast-iron air boxes with the air supply for each controlled independently by an air gate operated from in front of the boiler. Each stoker unit is supported at the front and at the bridge-wall, so that where more than one stoker per boiler is installed, one element does not depend on the other for support. By the use of forced draft the supply of air as well as coal may be automatically controlled by the steam pressure. The operation of the refuse-disposal mechanism is similarly controlled.

As shown in Fig. 2, the retort has a horizontal top on which are mounted tuyere blocks to provide air under pressure, the fuel being fed to the retort by a steam-



FIGS. 1, 2 AND 3. SHOWING DETAILS OF MOLOCH UNDERFEED STOKER

Fig. 1—View of two-retort equipment. Fig. 2—Cross-section through furnace. Fig. 3—Side elevation showing refuse disposal mechanism

operated ram supplied from the hopper attached to the ram cage. The operation of the ram is intermittent and automatically regulated, each charge delivering approximately 12 lb. of coal to the retort. The tuyere openings supply the air necessary for combustion below the fire, but above the fresh fuel. The heat of the fire above drives off the volatile matter, as is done in any coking process, and these gases thoroughly mixed with the necessary air supply pass through the zone of combustion and are consumed. The coke passes upward into the zone of combustion and out of the retort into an expanding mass above, where it is consumed, the refuse passing over the tuyere blocks to the rotary grinders, which remove it from the furnace. An outstanding feature of the present stoker is that the coke rising out of the retort at the rear is in the same condition for final consumption as that which rises out near the front wall, and the refuse which is produced at or near the front wall is removed at that point, this being true all the way along the retort. The action of the coke in swelling and spreading out of the

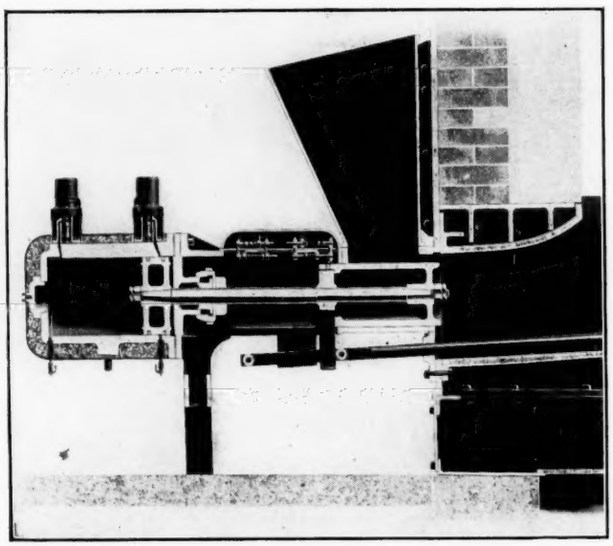


FIG. 4. CYLINDER AND RAM

retort forces the refuse ahead of it, thereby causing a mechanical slicing of the fire at each charge of fuel. This action is practically continuous, resulting in the fire being constantly in motion and preventing the formation of large clinkers.

To obtain maximum efficiency with any stoker, automatic regulation of fuel and air-supply is a necessity. In the present case the speed of the forced-draft fan is varied in accordance with the load demand by the usual fan-engine regulating valve or steam-controlled motor-speed regulator. Two methods of actuation are used, depending on the requirements of the installation. One employs steam pressure to operate differential steam valves at the stoker cylinder; the other employs electric current to operate balanced valves at the stoker cylinder by means of solenoids. The fan engine or motor, as the conditions require, drives, by means of a belt or through countershafting, a selective timer which operates a pilot valve or electric contactor, depending on the system used. This timer can be placed at any convenient point.

Each stoker cylinder is provided with two steam valves, one to control the outward and one to control the inward movement of the ram. For the steam type the pilot valve operated by the timer supplies pressure to the valve on the ram end of the stoker cylinder, causing it to lift and allow steam from the supply pipe to flow to the cylinder. The consequent movement of the piston withdraws the ram to receive the coal. Through the pilot valve the timer then exhausts the pressures on one side of the stoker valve, thus shutting off the steam supply and opening the exhaust. Simultaneously the pilot valve allows pressure to flow to the stoker valve on the head end so that the ram may push the charge of coal into the retort, a pusher rod in the bottom of the retort continuing the movement to the far end of the furnace.

For the electric type the timer, on making a contact, energizes the solenoid of the valve on the ram end of the stoker cylinder, causing it to lift and then operating in the same manner as described for the steam type. A local interlocking equipment at each stoker, however, controls the operation of the valve on the head end, reducing the steam consumption to a minimum. The timer can be adjusted manually on five variations of speed and one off position which will stop the stoker operation. The rate of feed of each stoker can be independently varied. A drop in steam pressure increases the air and fuel supply, and vice versa, without attention from the operator, at the same time increasing or diminishing the rate of rotation of the rotary grinders.

To provide for expansion and contraction as well as possible faulty operation, the retorts are made in sections—one large lower front section, a lower rear section and a divided upper section. The joints are made tight with asbestos furnace cement. Any section cracked will remain in position and be of service, but can be replaced without disturbing any other section.

The air boxes are cast-iron plates attached to and hung from retort supports, being made in sections with a removable bottom. The tuyeres are provided with fins on the inside to take up the heat from the fire surface and dissipate it to the incoming air, thus serving two functions; namely, to increase the life of these sections and to preheat the air for combustion.

The pusher rod is secured to the bottom of the retort by an inner bearing. It receives its motion from the piston rod of the ram. The pusher blocks are mounted on the rod in two halves secured together so that they can be easily replaced or moved along the rod. The boiler fronts are made sectional and so arranged that any panel can be removed without disturbing any other. The fire-doors are carried on frames bolted to the front panels, the edges of the frames extending through the thickness of the front casting, thus protecting the front from the heat of the furnace and allowing the frame to be renewed instead of the entire panel. The handle for opening the door is also a lock. When the door is closed, the handle is parallel with it and engages a stop on the frame. Upon grasping the handle and pulling it to a horizontal position, the door unlatches and opens.

For plants having boilers of small or medium size and only two or three units without a basement or ash-disposal equipment, a stoker has been designed in which the refuse-disposal mechanism has been omitted. Otherwise the design and arrangement are practically the same as in the self-cleaned stoker. The underfeed principle and forced draft are used with automatic regulation of fuel and air supply controlled by the load demand and actuated by the boiler pressure.

Clinkering of Bituminous Coal--IV*

By F. C. Hubley†

SYNOPSIS—Discusses chiefly the behavior of clinker which is re-fused by not having been removed from the fire at the first cleaning, after which the clinker formed.

As previously stated, the fusibility of a run-of-mine coal ash will be, in the case of most mines, a variable, depending on the degree of preparation and inspection that the shipment has been subjected to before leaving the mines. In other words, the fusibility of the "true" ash and "parting ash" will sometimes vary widely, therefore the run-of-mine sample will be affected according to the variable percentage of "parting" ash contained in the output of the mine.

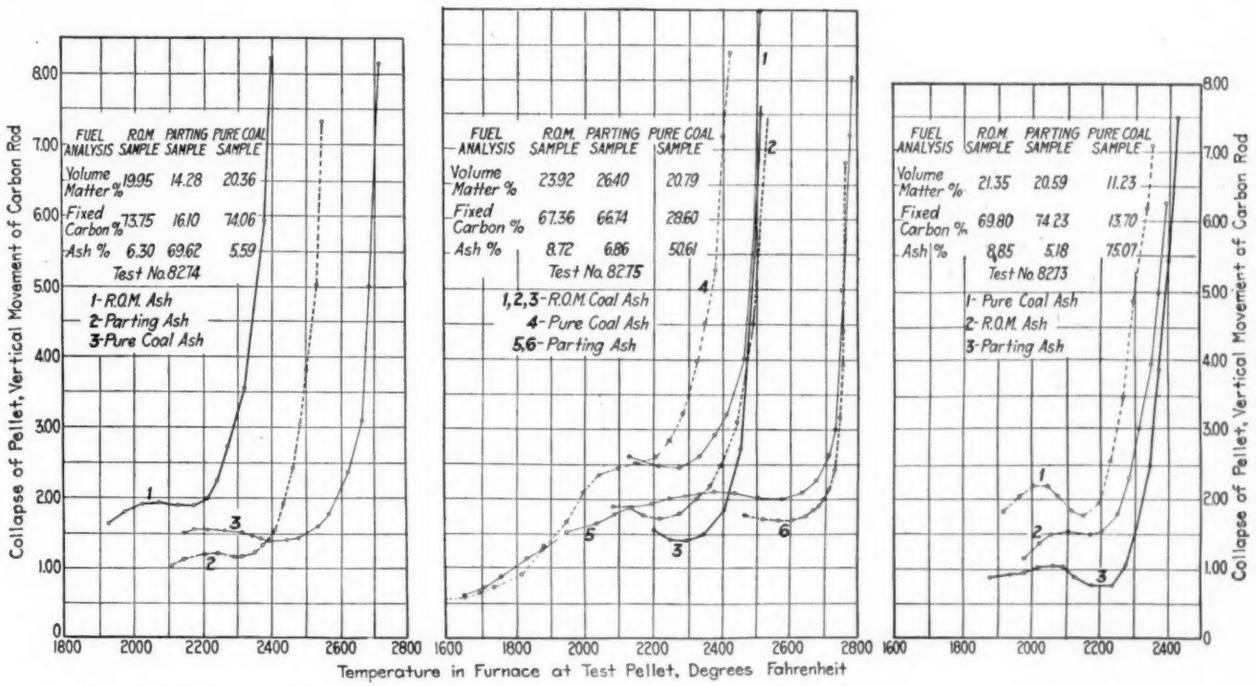
The output from a number of middle Pennsylvania mines was investigated, with a view of obtaining definite information on this subject, the samples being taken as follows: The sample for "true ash," or pure coal, was selected from the top of the car, only the pure crystals of coal being included; the sample for "parting ash," or bone, was selected from the top of the car, only the bone and definite "parting" fragments being included; the run-of-mine sample was obtained by passing the entire car load through a crusher and obtaining a 1,200-lb. sample with an automatic sampler.

From a number of shipments investigated in this manner three cases have been selected to illustrate the three general conditions existing in the mines. From an inspection of the curves it is apparent that two factors control the position and shape of the run-of-mine ash curve—first, the relative fusibility of the "true" ash and "parting" ash, and second, the relative fluxing effect of the true and parting ash on each other.

For example, in Fig. 19 this relative fluxing effect has apparently reduced the melting point of the run-of-mine ash (curve 1) below that of either the true or the parting ash. The pure-coal ash (curve 3) is highest in fusibility, the three samples being separated by about 150 deg. F.

In Fig. 20 the ash fusion (curves 1, 2 and 3) has an intermediate position, but closer to the true ash fusion (curve 4). The parting ash (curves 5 and 6) fuses at quite a high temperature, and in the case of this mine poor preparation would probably increase the fusing point of the run-of-mine coal ash.

Fig. 21 is the third condition met with, in which the pure coal ash (curve No. 1) is lowest, the run-of-mine ash



FIGS. 19 TO 21. RESPECTIVELY SHOWING VARIATION BETWEEN PURE COAL ASH, PARTING ASH AND RUN-OF-MINE ASH

In regard to comparing laboratory results with those obtained in boiler house, Somermeier[1] notes " . . . . that fusibility of well-mixed ignited ash and fusibility of the ash in the coal during combustion in a furnace are two entirely different things. The first is dependent upon the constituents of the ash as a whole; the second

*For other articles of the series see "Power" for Oct. 10, 17 and 24.

†Engineer, American Bridge Co.

[1]"Coal," p. 5.

is dependent upon the nature and distribution of the different minerals in the coal acting separately or only partly mixed."

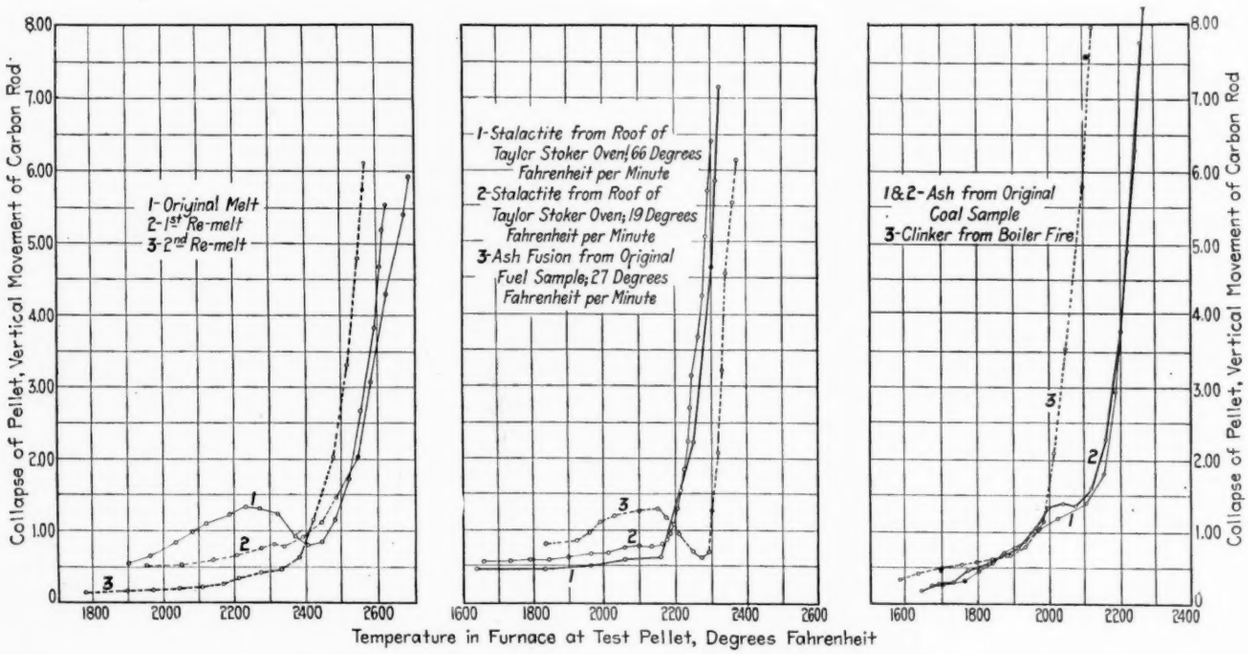
Another factor which would tend to defeat the comparison of laboratory with boiler-room results is the continual re-fusion of the clinker between cleaning periods in the boiler fire. This is especially true where the boiler load is subject to violent fluctuations, as in rolling-mill practice.

With a variable load, the fuel-bed temperature may change from possibly 2,000 deg. F. to the maximum temperature many times between cleaning periods, in which case the clinker, which was perhaps initially formed at a high temperature, appears to change radically in fusing range and nature of fusion under the influence of repeated re-fusion. Practical firemen state that a fuel which produces a not too troublesome clinker will, if not coking coal having a low fusing ash. After depositing on the tubes, re-fusing of this clinker probably assisted in the building down of this clinker structure. Curve 3 is developed from a sample of this clinker.

Another case may be cited where the clinker built up from the top of the bridge-wall, closing off the gas-passage area in the same manner, and probably owing to the same causes.

In Fig. 25 (curve 1) is illustrated the curve from a very high-fusing ash which gave no trouble at all at cleaning periods, except at intervals when a single clinker of rather large dimensions and hardness would have to be removed. Curve 2 was developed from a general sample of one of these clinkers, showing a long softening range and a viscous gummy formation.

Curve 3 shows some of the ash mixed with 30 per cent. of the 100-mesh coal sample from which it was derived.


Collapse of Pellet, Vertical Movement of Carbon Rod
1- Original Melt
2- 1st Re-melt
3- 2nd Re-melt
1- Stalactite from Roof of Taylor Stoker Oven; 66 Degrees Fahrenheit per Minute
2- Stalactite from Roof of Taylor Stoker Oven; 19 Degrees Fahrenheit per Minute
3- Ash Fusion from Original Fuel Sample; 27 Degrees Fahrenheit per Minute
1&2- Ash from Original Coal Sample
3- Clinker from Boiler Fire
Temperature in Furnace at Test Pellet, Degrees Fahrenheit

FIGS. 22 TO 24. RESPECTIVELY SHOWING RESULTS OF RE-FUSION

removed at the first cleaning after it formed, give excessive trouble in removal at the next succeeding cleaning period. The sample represented in Fig. 22 could give trouble of this nature, not because of the reduced temperature at which this ash re-fuses, but because of a change in the nature of the fusion from a porous voluminous mass to a close gummy formation. This gummy formation is more noticeable in the second re-fusion.

Fig. 23 (curve 3) shows a low fusing ash which at times formed a clinker that could be handled, while at other times excessive trouble was caused, either by protracted high temperatures in the fuel bed or re-fusion of the clinker. Curves 1 and 2 represent the fusion of a stalactite of clinker from the roof of the furnace, after an extended use of this fuel.

In Fig. 24 (curves 1 and 2) a fuel is represented which built clinker downward from the oven roof, closing the gas-passage area between the tubes, directly over the bridge-wall of a vertical boiler. This occurred to so great an extent that the boiler had to be frequently shut down and the clinker removed. The probable explanation of this occurrence lies in the combination of a poor

The effect of raising the apparent melting point in this ash is similar to the effect of an excess of dextrin shown in previous illustrations.

The investigations described in these articles lead one to conclude that in formulating specifications to control the clinkering tendency of coal used in steam boilers many factors must be established and related to one another before such a specification will be effective in protecting the steam user against losses.

First—There is the adoption of a standard laboratory test for ash fusion in which the following details are to be considered: (a) General method of the test; (b) atmosphere surrounding the test piece during fusion; (c) use of a binder in forming the test piece; (d) fineness of the ash previous to molding into test piece; (e) definition of "thoroughly incinerated ash"; that is, the maximum allowable percentage of carbon to remain in the ash previous to molding into the test piece; (f) shape of the test piece; (g) rate of heating during fusion test; (h) temperature range of the apparatus; (i) definition of arbitrary point to be called the melting point of the sample.

Second—The relation between results of the standard laboratory test and those obtained in practice in the boiler fuel bed. With several laboratories using the standardized test, a number of special cases of clinker formation with various kinds of boiler equipment will have to be investigated before this relation can be established. Probably it would be well to confine such investigations to plants where heavy overloads are carried

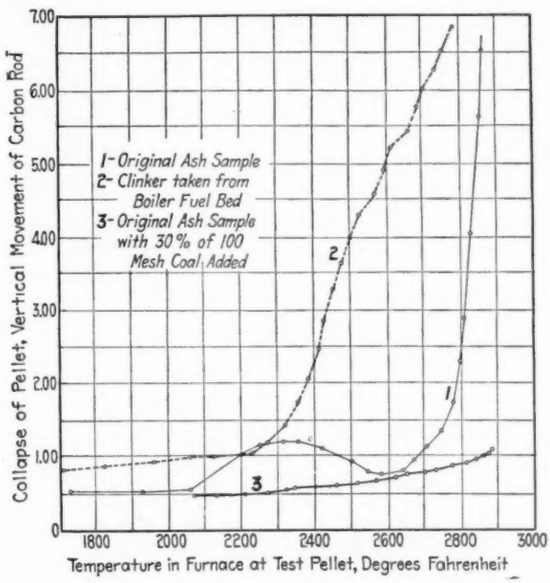


FIG. 25. ORIGINAL ASH COMPARED WITH SAMPLE WITH 30 PER CENT. COAL ADDED

for short periods; for while the large steam user is interested in what occurs at 2,250 deg. F., or the fuel-bed temperature corresponding to a boiler operating at rating, he is much more concerned with the possibility of steam failure at his highest peak loads. In addition to fuel-bed temperatures and the load on the boiler, note should also be made of the possibility of re-fusion occurring in the fuel bed between fire-cleaning periods.

Third—The final item to be established is the form of clause, based on the foregoing information, to be inserted in the coal specifications. If 2,700 deg. F. or over is specified for the so-called "melting" point of the ash, it is probable that this specification alone will be ample protection against clinker formation. This figure, while including the output of a number of mines in the Middle Pennsylvania and West Virginia fields, would much restrict the buying field in some localities. Therefore, where the melting point is specified at 2,600 deg. F. or under, it would appear necessary to include some mention of viscosity or nature of fusion to have the specification effective.

This article completes the series.

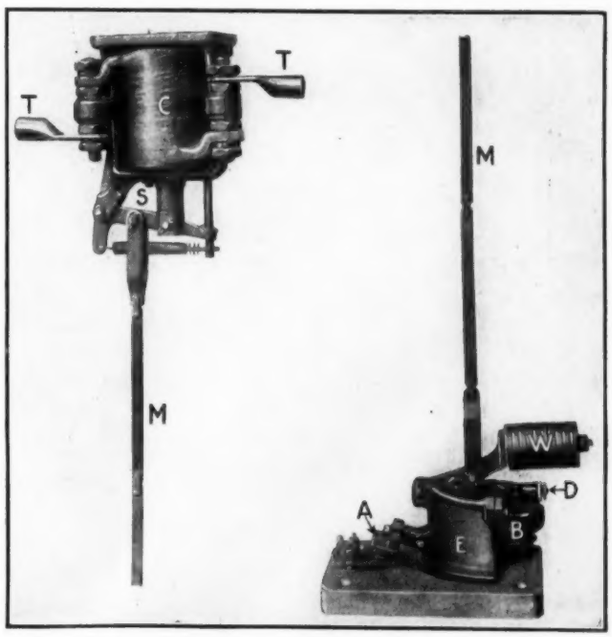
The Wheel and Axle commonly used as a windlass to hoist objects affords a good illustration of the principle in mechanics that "a loss of speed produces a gain in force, and a gain in speed reduces or diminishes the force." It is evident that the velocity of the circumference of the wheel is as much greater than that of the axle as it is farther from the center of motion. The rim of the wheel describes a great circle in the same time that the axle describes a small one; therefore the force at the axle is increased in the same proportion as the circumference of the wheel is greater than that of the axle. If the velocity of the periphery of the wheel is twelve times greater than that of the drum or axle, the force of 1 lb. on the wheel will sustain a weight of 12 lb. on the axle.

High-Voltage Overload Relays for Alternating Current

For high-voltage stations requiring overload protection where the extra cost of current transformers prohibits the use of extremely accurate relays, the one illustrated is an economical substitute. This relay was recently brought out by the Westinghouse Electric and Manufacturing Co., and affords ample overload protection with a fairly accurate time element. It is designed for indoor use and is suitable for operation on high-voltage alternating-current circuits of any frequency.

This relay, known as the type HB, consists of a strongly built solenoid mechanism *S* which operates a timing and circuit-closing element *E* through a micarta chain *M* of such length as to provide ample insulation for the voltage in use. There is no lost motion in the chain as it is constantly held in tension by the weight *W*, the action of the solenoid raising the weight. For voltages up to 44,000 the chain consists of 12 links. Twenty links are provided for voltages up to 66,000, and 30 links up to 110,000 volts. The links may be removed to shorten the chain, down to a minimum of one link for each 6,600 volts.

The relay coil *C* is inserted directly in the high-voltage line by the terminals *T*, but the contacts and timing parts *E* are thoroughly insulated and can thus be



RELAY FOR OVERLOAD PROTECTION ON HIGH-VOLTAGE ALTERNATING-CURRENT CIRCUITS

handled, adjusted or tested without disconnecting the feeder. The coil can be mounted on a disconnecting switch or choke coil and the use of separate insulators avoided, while the contact mechanism can be mounted in the position most convenient.

This relay is built in two forms—one having an inverse-time element, the other a definite-time element. The inverse-time-element relay can be set practically instantaneously. In this form of relay the solenoid and chain are opposed in their motion by a bellows *B* with an adjustable valve *D*. The valve has a small numbered dial which

permits of any setting between a maximum time element of about 20 sec. at 25 per cent. overload and a minimum of about 1 sec. at the same overload. With greater overload the relay acts in a shorter time.

In the definite-time-element relay the same kind of bellows and valve is used as for the inverse-time limit, but the solenoid chain does not act directly on it. The core and chain rise instantly on overloads and compress a spring that in turn acts on the bellows. If the overload continues for the time for which the relay is set, the tripping contacts *A* close. The time required for the spring to close the contacts depends only on the setting of the valve and is entirely independent of the magnitude of the overload. The relay can be set for any time element between one and ten seconds.

The minimum current at which the relay will trip depends on the number of weights *W* placed on the arm of the contact-making mechanism. This can be varied from 80 to 160 per cent. of the rated current of the relay.

As the type HB relays are controlled by bellows, they are not as accurate as to time element as magnetically damped relays. Their time element, however, will be found sufficiently accurate to afford protection on the circuit to which they are intended to be applied, though selective protection with regard to other circuits in the system cannot always be satisfactorily obtained.

This type of relay is intended for mounting on disconnecting switch or other support on the high-tension line, but insulating supports can be furnished where necessary. One relay is required to protect a single-phase circuit, two relays for a two-phase or three-phase ungrounded neutral circuit and three relays for a three-phase grounded-neutral circuit.

A New Use for Sheet Packing

An engine was pounding badly, and the distracted engineer (excuse the term), failing to ascertain the cause of the trouble, called upon a neighboring engineer to come over and see if he could end the rumpus. He came and found that Mr. Starterandstopper had used sheet packing as a shim on the outer end of the crank rod.

[No wonder the central station gets some of them.—Editor.]

To the Young Engineer

George H. Diman, the veteran consulting engineer of the American Woolen Co., recently sent the following three questions to the Lawrence, Mass., branch of the N. A. S. E. to be asked the young men at one of the weekly meetings:

How many of you have ever been to your employer and asked what you could do to help him to save a dollar in expenses?

How many of you have ever asked your employer what you could do to increase the production of his plant?

How many of you are careful of your machinery to keep it in such order as to cause no delays from stoppage and consequent expense to your employer?

Mr. Diman has always had the welfare of the young engineer at heart. It was his opinion that the foregoing questions specify the things they must do to increase their value to their employers and incidentally to better themselves financially. Otherwise, he considered the following verses appropriate:

NOT HIS JOB

By Edgar A. Guest, in Detroit "Free Press"

"I'm not supposed to do that," said he,
When an extra task he chanced to see;
"That's not my job, and it's not my care,
So I'll pass it by and leave it there."
And the boss who gave him his weekly pay
Lost more than his wages on him that day.

"I'm not supposed to do that," he said,
"That duty belongs to Jim or Fred."
So a little task that was in his way,
That he could have handled without a delay,
Was left unfinished; that way was paved
For a heavy loss that he could have saved.

And time went on and he kept his place,
But he never altered his easy pace,
And folks remarked on how well he knew
The line of the tasks he was hired to do;
For never once was he known to turn
His hand to things not of his own concern.

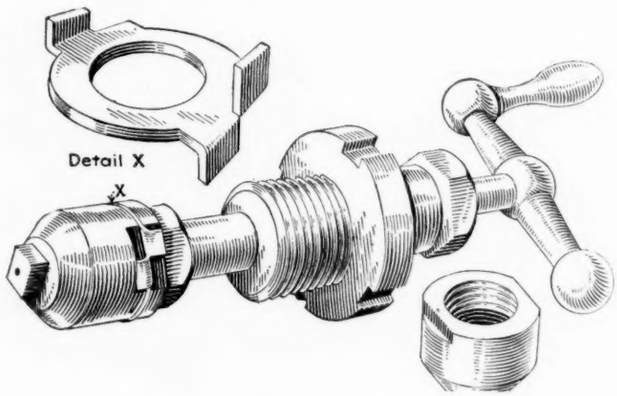
But there in his foolish rut he stayed,
And for all he did he was fairly paid,
But he never was worth a dollar more
Than he got for his toil when the week was o'er;
For he knew too well when his work was through,
And he'd done all he was hired to do.

If you want to grow in this world, young man,
You must do every day all the work you can;
If you find a task, though it's not your bit,
And it should be done, take care of it;
And you'll never conquer or rise if you
Do only the things you're supposed to do.

Lock for Valve Disk Nut

By F. W. Bentley, Jr.

The valve disk and nut of the design ordinarily used frequently cause trouble, for when loosened the action of the steam soon frees the disk and allows it to seat and shut off the flow. The illustration shows an excellent method of locking them in place, which may be of interest. A flat place is filed on both sides of the disk parallel with the flat or wrench portions of the nut. The lock washer is made of thin sheet metal having four lugs: one of each pair is bent up on the nut and the other down on the disk. Even should the disk and nut become loosened, it will not free itself from the nut.



LOCK WASHER IN POSITION

Air Is Withdrawn from Surface Condensers by an air pump. If the withdrawal takes place at the temperature corresponding to the condenser pressure, the pump has to deal with an enormous air volume. The air temperature should therefore be lowered, at the point where it is withdrawn, below the saturation temperature for the condenser pressure.

Boiler Explosions, July 1, 1915, to July 31, 1916

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
July 3	Fredonia, Kansas	Ray Brown	6:00 a.m.	Portable	110	25 hp.	0	1	$550	Unknown
July 5	Easly, S. C.	Easly Cotton Mills		Water-tube			0	0		Tube rupture
July 7	Green River, Wyo.	Western Alkali Mfg. Co.	11:00 a.m.	Marine	125	125 hp.	0	0	Boiler	Scale and low water
July 7	Jefferson, Ky.	Owen's Thresher					0	1		
July 8	Dunbar, Penn.	Semet Solvay Co.		Water-tube			0	0		19 cast-iron headers ruptured
July 10	Near Springfield Mo.	J. Clark Portable Thrasher	1:00 p.m.	Traction engine	110	20 hp.	0	1	$2,000	Over pressure on welded patch
July 12	New Bedford, Mass.	Garcia Bros. Bakery	7:15 p.m.	Hot-water-tank		50 gal.	1	2		Stoppage of water supply
July 12	Wau' egan, Ill.	American Steel & Wire Co.		Water-tube			0	0		Seven cast-iron headers fractured
July 14	Quigley, Ark.	G. H. Bonner & Sons Sawmill					0	0		
July 14	Near Springfield, Mo.	Kerchner Bros. Portable Drill Rig	3:00 p.m.	Upright	80	12 hp.	0	2	$800	Low water—boiler corroded
Jul' 14	Clearfield, Pa.	Allen & Bartholemew Cleaning Works	10:30 a.m.	Upright	80	36" x 0'	0	2	$2,800	Low water—bottom flue sheet failed
Ju / 15	Humble, Tex.	Farmers' Oil Co.	5:30 a.m.	Locomotive type	120	45 hp.	0	1	$700	Low water
July 15	North Creek, N. Y.	State Road Contract	3:00 p.m.		20		0	2	$75	
July 19	Chicago, Ill.	S. C. Schenck Co.'s Coal Yards	2:00 p.m.	Horizontal tubular	125	100 hp.	0	0	$150	Blowoff pipe failure
July 20	Cleveland, O.	City Ice Delivery Co.		Horizontal return-tubular	100	72x18	0	0		Low water—blowoff left open
July 20	Canton, N. C.	Champion Fibre Co.	2:15 p.m.	Locomotive	150	36-ton loco.	0	2	$650	Low water
July 22	Huntsville, Ala.	Merrimac Mfg. Co.	2:10 p.m.	Water-tube	200	350 hp.	1	1	$50	Unknown
July 23	Suffolk, Va.	Virginia Railway & Power Co.	11:30 a.m.	Water-tube	100	150 hp.	0	1		Unknown
July 23	Columbus, Kan.	Columbus Milling Co.	2:45 p.m.	Tubular	50	80 hp.	0	0	$1,500	Excess pressure—faulty safety valve
July 24	Hudson, N. C.	Justice's Sawmill	1:00 p.m.	Portabl	125	15 hp.	1	1	$1,500	Excess pressure
Aug. 5	Piercefield, N. Y.	Highway Stone Crusher	4:00 p.m.	Locomotive type	97	25 hp.	1	0	$150	Crown sheet stays failed—over pressure
Aug. 20	Iowa Falls, Ia.	J. M. Collins' Farm		Traction engine	120	22 hp.	1	1		Low water
Aug. 21	Wharton, Ark.	Burgess' Sawmill	11:30 a.m.		130	30 hp.	2	2	$150	Unknown
Aug. 23	Chattanooga, Tenn.	Empire Barber Shop	8:00 a.m.	Vertical single tube*	100	12x36	0	1	$200	Valve in pipe closed caused overpressure
Aug. 24	St. Louis, Mo.	M. & O. Roundhouse		Locomotive	100		0	1		Collapsing of boiler tube
Aug. 26	Baltimore, Md.	Simmons' Cannery					1	14		Old boiler
Sept. 1	Snow Camp, N. C.	Johnson & Fuquay Saw Mill	2:00 p.m.	Locomotive type	120	30 hp.	3	2	$300	Unknown
Sept. 3	Devils Lake, N. D.	Thresher Boiler	9:30 a.m.	Locomotive type	150	25 hp.	1	1	$2,000	Low water; bolt in soft plug
Sept. 8	Windsor, Va.	Sawmill	10:30 a.m.			22 hp.	0	3	$100	Weakened from rust
Sept. 28	Texas City, Tex.	Pierce Fordyce Oil Refinery	3:20 a.m.	Horizontal-return-tubular	100	150 hp.	1	0	$15,000	Excessive pressure
Sept. 28	St. Henry (Montreal), Que.	St. Henry Syndicate (Dept. Store)	5:05 p.m.	Cast-iron heating			0	5	$5,000	Stop valves closed; safety valve failed
Sept. 29	Natchitoches, La.	Felix Rachal's Gin			110		7	2		
Oct. 1	Alexandria, La.	Henryville Gin	10:30 a.m.	Old-time two-flue	80		6	1	$500	
Oct. 2	Round Rock, Tex.	Nelson Oil Field	9:00 a.m.	Locomotive type	100	30 hp.	1	0	$550	Low water
Oct. 2	New York, N. Y.	Knowlton Court—Apartment House		Return-tubular		50 hp.	0	1	$300	Coal gas
Oct. 3	Austin, Tex.	Houston & Texas Central Passenger Train	a.m.	Locomotive			0	0		Crack in longitudinal seam
Oct. 5	Evans City, Penn.	Datt-Lot Well	8:00 a.m.	Locomotive type	90	35 hp.	0	1	$10	Defective crown sheet
Oct 6	McKittrick, Cal.	Producers' Transportation Co.	2:00 a.m.	Scotch marine	125	125 hp.	0	1		Unknown
Oct. 8	Lynchburg, Va.	Norfolk & Western R.R.	10:30 a.m.	Freight locomotive		8-wheel	1	1	$25,000	Low water
Oct. 9	Salem, S. D.	Clark's Farm	1:30 p.m.	Marine	120	22 hp.	0	1	$400	Low water
Oct. 9	Shubuta, Miss.	Brownle Lumber Co.	6:30 p.m.	Locomotive			2	12	$1,500	Low water and burned crown sheet
Oct. 10	Shamrock Station, Penn.	Pennsylvania, R.R.		Locomotive			0	3		
Oct. 11	Near Andalusia, Ala.	Horseshoe Lumber Co.	10:00 a.m.	Industrial locomotive	200		1	1	$2,500	Low water
Oct. 11	East Weymouth, Mass.	Geo. E. Strong & Co.'s Shoe Factory	7:45 a.m.	Fire-tube lap-seam	80	72x18'	1	50	$10,000	Failure of lap seam
Oct. 12	Fresno, Calif.	Hotel Tulare	8:00 p.m.	Gas heating		7x2'	0	0	$50	Defective construction
Oct. 15	Belle River, Ont., Can.	Marentette Farm	3:00 p.m.	Horizontal	100	20 hp.	0	2	$700	Defective plate seam gave way
Oct. 17	Lockport, La.	Lock-Moore Co., Ltd.	9:00 a.m.		125		1	1		Break in steam pipe
Oct. 18	Mobile, Ala.	Hieonymus Bros. Saw Mill	2:10 p.m.				0	5	$3,000	
Oct. 19	Abbottsford, Mich.	Westbrook, Brick Yard	10:30 a.m.			19 hp.	1	5		
Oct. 23	Lovelady, Texas	Lang Smith's Cotton Gin	1:30 p.m.	Return tubular	80		5	3	$5,000	Low water
Oct. 24	Richmond, Va.	Young Women's Christian Ass'n		Cast-iron sectional			0	0		Section ruptured
Oct. 24	Shamokin, Penn.	Susquehanna Coal Co.	a.m.	Water-tube	125	125 hp.	0	1		Rupture of lap-riveted seam
Oct. 25	New York City	Apt. House, Morningside Ave.		Cast-iron sectional heating			0	0		Section ruptured
Oct. 26	New Augusta, Miss.	Meyer & Oliver Sawmill	4:00 p.m.				0	4		Low water
Oct. 28	Greenwood, S. C.	The Grendell Mills (Mill No. 1)					0	0		Blow-off failed
Oct. 29	Auburn, N. Y.	Empire Gas & Electric Co.					0	1		Tube rupture
Oct. 30	E. Rutherford, N. J.	Zahn & Bowly Co.		Water-tube			0	0		Tube ruptured
Oct. 30	Bogalusa, La.	New Orleans Gt. Northern R.R.		Locomotive			1	1		Crown sheet collapsed
Nov. 3	Lenore, Ky.	Traction Engine	3:30 p.m.	Locomotive type	115	16 hp.	1	1	$300	Unknown
Nov. 5	New Haven, Conn.	Winchester Repeating Arms Co.		Water-tube			0	2		Three cast-iron headers ruptured
Nov. 5	New York City, N. Y.	Horn & Hardhart, W. 42nd St.					0	0		Three sections cracked
Nov. 10	Danvers, Mass.	J. F. Brown's Moving Picture Theatre		Cast-iron sectional	5		0	0	$150	Section ruptured
Nov. 11	Cross Keys, Penn.	Chas. Stiffler Sawmill	8:00 a.m.	Sawmill	80	10 hp.	2	4		
Nov. 11	New York City, N. Y.	Loew's Theatre, 1022 So. Boulevard		Cast-iron sectional			0	0		Section ruptured
Nov. 11	New York City, N. Y.	General Theological Seminary	10:30 a.m.	Sectional	10		0	0	$250	Explosion of gas in firebox
Nov. 12	Oliver Springs, Tenn.	Electric Light & Power Co.	9:30 p.m.	Return-tubular	110	60 hp.	0	1		Water glass valve burst
Nov. 13	Aberdeen, Wash.	Anderson & Middleton Lumber Co.		Water-tube			0	0		Tube failure
Nov. 15	Bogalusa, La.	Gt. Southern Lumber Co.'s Hospital		Cast-iron sectional heating			0	0		Six sections cracked
Nov. 16	Ada, Okla.	The Irving School		Cast-iron sectional heating	10	6-sectional	0	0	$250	Low water
Nov. 16	Beloit, Kans.	W. E. Blood's Drug Store		Cast-iron sectional			0	0		Two sections cracked
Nov. 16	Near Worthington, W. Va.	Caroline Mine of Consolidation Coal Co.	p.m.				2	0	$30,000	Low water
Nov. 19	Tenino, Wash.	Capitol Shingle Co.		Tubular	130	60x16	0	1	$90	Blowoff pipe ruptured
Nov. 20	Ashtabula, O.	The Pollock Becker Co.		Water-tube			0	0		Six cast-iron headers ruptured
Nov. 20	Hurley, Wis.	Montreal Mining Co.	3:00 p.m.	Water tube boiler	130	150 hp.	0	0		Scale caused tube rupture

* Collapsed at top end. Boiler had once been sold as scrap.

BOILER EXPLOSIONS, JULY, 1915, TO JULY, 1916—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Nov. 23	Windsor Locks, Conn.	Primary School	2:45 p.m.	Cast-iron heating	1½	24′	0	0		Flaw in rear section casting
Nov. 23	Cumberland, Md.	Home of A. A. Doub, 106 Washington St.	2:00 p.m.	Heating			0	0	$1,500	
Nov. 24	Pottsville, Penn.	Mill Creek Coal Co.		Vertical fire-tube	80	75 hp.	2	0	$2,000	Low water caused overheating
Nov. 27	Fort Worth, Texas	Santa Fe Pumping Plant	6:00 a.m.				2	0		Crown sheet failure
Nov. 27	Jersey City, N. J.	American Sugar Refining Co.					0	3		Boiler tube blew out
Nov. 27	Cummings, S. C.	C. W. Cummings Sawmill		Locomotive type			0	0		Crown sheet collapsed
Nov. 28	Johnstown, Penn.	Y. M. C. A. Building		Cast-iron sectional heating			0	0		Seven sections ruptured
Nov. 29	Pontiac, Mich.	M. Livingston's residence	8:00 a.m.				0	0		Excessive pressure
Nov. 30	South Chicago, Ill.	By-Products Coke Co.		Water-tube	150	500 hp.	0	0		Seven cast-iron tube headers ruptured
Nov. 30	Hays Station, Penn.	Harbison Walker Refractories Co.	6:30 a.m.	Vertical-water-tube	125	96x33	0	0		Tube ruptured
Dec. 1	Lansing, Mich.	The Lansing Co.	1:30 p.m.	Water-tube	100	50 hp.	0	2	$50	Tube ruptured
Dec. 1	Ludington, Mich.	Morton Salt Co.		Water-tube			0	0		Tube rupture
Dec. 1	Jersey City, N. J.	Howard D. McGeorge		Cast-iron sectional heating			0	0		Section ruptured
Dec. 2	Centralia, Ill.	Chicago, Burlington & Quincy R.R.		Locomotive			0	2		
Dec. 2	Sturgis, Mich.	Clayton & Sterns		Hot-water-heater			0	0		
Dec. 2	Near Burlington, Colo.	Fred Dodd's Farm	10:00 a.m.	Locomotive type	140	20 hp.	1	1	$400	Unknown
Dec. 3	Kingston, Penn.	Peters Paper Co.	1:30 a.m.		65		0	2	$78,000	Excessive pressure
Dec. 3	George School, Penn.	George School	10:00 a.m.	Cast-iron sectional	70	120 hp.	0	1		Scale caused overheated unit
Dec. 3	South Bend, Ind.	The Lamb Shirt Co.	7:00 a.m.	Cast-iron sectional	15	6 sections	0	0		Unknown
Dec. 4	Seymour, Ia.	East Ward School	5:00 p.m.	Cast-iron heating	12		0	0		Section ruptured
Dec. 4	Near Columbus, Miss.	Cox Gin and Grist Mill	5:30 p.m.				3	4		Low water
Dec. 5	Cadoma, Wyo.	Burlington R.R.	a.m.	Locomotive			1	2		
Dec. 5	York, Penn.	K. G. E. Hall		Heating			0	0		
Dec. 6	Near Lake Charles, La.	Krause Mangen Lumber Co.		Locomotive			2	0		
Dec. 7	Hanging Rock, O.	Hanging Rock Iron Co.		Water-tube			0	0		Tube rupture
Dec. 8	Arthur, W. Va.	Norfolk & Western R.R.		Locomotive			1	3		Unknown
Dec. 8	Dayton, O.	Barney & Smith Car Works	5:10 p.m.	Horizontal water tube	120	250 hp.	1	1	$100	Burst tube blew out 9 headers
Dec. 9	High Falls, Ky.	R.R. Pumping Station	10:a.m.	Upright	100	6½x3¾	1	1	$200	Low water
Dec. 10	Brooklyn, N. Y.	B. R. T. Power House		Water-tube			0	2		Tube rupture
Dec. 10	Kansas City, Mo.	Cunningham & Brokerage Co.		Cast-iron sectional			0	0		Section ruptured
Dec. 11	Quincy, Mass.	Quincy Real Estate Trust		Cast-iron heating			0	0		Tube failure
Dec. 11	Kentwood, La.	Brooks-Scanlon Co.	6:30 a.m.	Locomotive	140	45 ton	1	1	$2,500	
Dec. 11	Baltimore, Md.	Grace M. E. Church	8:00 a.m.	Sectional cast-iron	2	13-section	0	0		Low water; 4 sections cracked
Dec. 12	Apalachicola, Fla.	Cypress Lumber Co.	10:00 p.m.	Two-flue	100	48″x30′	0	0	$500	Water leaked out of blowoff pipe
Dec. 14	W. Reading, Penn.	Metropolitan Electric Co. Power House		Water-tube			0	1		Tube burst
Dec. 14	Seymour, Ia.	East Ward School*	9:30 p.m.	Cast-iron heating	7	7 section	0	0	$65	Section ruptured
Dec. 16	Philadelphia, Penn.	Linde Air Products Co.		Cast-iron sectional	10		0	1	$10	Four sections ruptured
Dec. 16	Plainfield, N. J.	Plainfield Union Water Co.		Water-tube			0	0		Tube ruptured
Dec. 17	Lynn, Mass.	J. B. Blood Co.'s Market		Cast-iron heating			0	0		Manifold ruptured
Dec. 17	Stonington, Me.	Steamship Vinal Haven					1	1		Boiler tube blew out
Dec. 18	Oakes, N. D.	General Utilities Co.					0	2		Blowoff pipe failed
Dec. 19	Near Cridersville, O.	Cincinnati, Hamilton & Dayton R.R.		Locomotive			0	3		Fusible plug blew out
Dec. 20	Philadelphia, Penn.	Queen Lane Pumping Station	1:00 a.m.	Water-tube	150	300 hp.	0	0	$1,000	Low water (regulator stuck)
Dec. 20	Near Troy, Ala.	Sawmill of Sam Dunn	2:30 p.m.	Return-tubular	120	44″x12′	1	2	$1,000	Low water
Dec. 20	Boston, Mass.	Chesterfield Hotel					0	2	$500	
Dec. 21	Buffalo, N. Y.	Lackawanna R.R.		Locomotive			0	2		Steam pipe burst
Dec. 22	Beverly, Mass.	Knowlton Garage	9:45 a.m.	Sectional heating	5	22″x4′	0	0	$500	Unknown
Dec. 22	Humble, Tex.	Farmers Petroleum Co.	1:00 a.m.	Locomotive type	110	40 hp.	1	2	$800	Low water
Dec. 24	Boston, Mass.	Jenceks Paper Box Co.		Cast-iron sectional			0	0		Section ruptured
Dec. 26	Oakes, N. D.	Oakes Lt. & Pr. General Utilities Co.*					0	0		Blowoff failed
Dec. 26	Ft. Dodge, Ia.	United Light & Railway Co.		Water-tube			0	0		Tube ruptured
Dec. 28	Near Altoona, Penn.	T. G. Thompson's Farm	Noon	Portable			2	0		Crown sheet gave away
Dec. 30	Springfield, Mass.	Standard Oil Co. of N. Y.		Cast-iron sectional heating			0	0		Section ruptured
Dec. 30	Columbus, O.	Round House of C., C., C. & St. L. R.R.		Water-tube			0	0		Tube ruptured
Dec. 30	Philadelphia, Penn.	Queen Lane Pumping Station	10:00 a.m.	Water-tube	150	300 hp.	0	0	$100	Water hammer in 10-in. header broke valve
Dec. 30	Holyoke, Mass.	Apt. Bldg. of E. Hugo Friedrich		Cast-iron heating			0	0		Four sections ruptured
Dec. 31	Alliance, O.	Lexington Hotel	5:00 p.m.	Cast-iron sectional	15	8 sections	0	0	Boiler only	Low water
Jan. 1	Newton, Mass.	R. C. Taylor Estate		Cast-iron sectional heating			0	0		Section failed
Jan. 1	Eureka, Ill.	Dickinson & Co. Canning Factory	4:00 p.m.	Cast-iron sectional	15	36x8	0	0	$500	Five sections ruptured—return check stuck
Jan. 3	Lampasas, Tex.	Santa Fe Railroad	6:00 p.m.	Locomotive			0	3		Unknown
Jan. 3	Silver Springs, N. Y.	The Worcester Salt Co.		Horizontal-tubular	80	72x120″	0	0		Muddy water, 2 boilers bagged at rear end
Jan. 4	Indianapolis, Ind.	Merchants Heat & Light Co.	5:30 p.m.	Water-tube	150	250 hp.	0	0	$600	Tube burst
Jan. 4	Wrightsville, Penn.	Hose Company					0	0		
Jan. 4	Sebastopol, Calif.	Sebastopol Steam Laundry					0	0		
Jan. 4	Moundville, Mo.	Bournsworth Sawmill	Noon	Return-tubular	150	18 hp.	0	2	$750	Unknown
Jan. 6	Franklin, Kan.	Joplin & Pittsburgh Railway Co.		Marine type			0	0		Furnace collapsed
Jan. 6	Near Elizabethton, Tenn.	Oliver Construction Co.	4:00 p.m.	Vertical	80	10 hp.	0	4		Old boiler
Jan. 7	Chicago, Ill.	Henry Bosch Co. Office Building		Cast-iron sectional heating	10		0	0		Valve left open—water drained out
Jan. 8	Miami, Fla.	Johnson & Co.'s Dredge Culebra		Marine type			0	0		Furnace collapsed
Jan. 8	Newark, N. J.	Sargeant Mfg. Co.					0	1		Blowoff pipe failure
Jan. 8	Haverhill, Mass.	Cushman & Hebert's Shoe Factory	10:00 a.m.	Horizontal-tubular	80	66″	0	0	$50	Blowoff pipe failure
Jan. 8	Buffalo, N. Y.	Steul & Thuman Mantel Factory					0	2		Blowoff pipe failure
Jan. 10	Charleston, S. C.	North State Lumber Co.					0	0		
Jan. 10	Near Ripon, Wis.	Freight Train		Locomotive			0	3		
Jan. 11	Navasota, Tex.	The Navasota Cooperage Co.	1:00 p.m.	Horizontal-tubular	125	18x60″	0	0	$10	Blowoff pipe failure
Jan. 12	Wauwatosa, Wis.	The Forsyth Leather Co.		Horizontal-tubular	95	72″x18	0	1		Blowoff pipe failure
Jan. 12	Windsor, Ont., Can.	Windsor Armory		Heating			0	1		
Jan. 12	Indianapolis, Ind.	Merchants Heat & Light Co.	5:30 p.m.	Water-tube	150	250 hp.	0	1	$300	Tube failure

* Second accident to same boiler inside of a month.

BOILER EXPLOSIONS, JULY, 1915, TO JULY, 1916—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Jan. 12	Alexandria, S. D.	Home of Senator Van Demark	8:30 a.m.	Range	60	30 gal.	1	0	$1,000	Frozen water pipes
Jan. 13	Glidden, Ia.	McNaught Shelving Factory		Heating			0	0		
Jan. 13	Near Harrisburg, Penn.	Philadelphia & Reading R.R. Yards	6:00 a.m.	Locomotive			0	2		
Jan. 13	Milwaukee, Wis.	Plankington Packing Co. of Swift & Co.		Water-tube	145	250 hp.	0	0		
Jan. 13	Preston, Ia.	Schoolhouse		Heating			0	0		
Jan. 14	New Haven, Conn.	Winchester Repeating Arms Co.		Water-tube			0	1		Cast-iron header ruptured
Jan. 14	Crete, Ill.	Henry Kindle's Barber Shop	7:00 a.m.	Hot water	45		0	0	$80	Freezing of circulating pipes
Jan. 15	Muscatine, Ia.	B. E. Lilly Store					0	0	$135,000*	
Jan. 16	Utica, N. Y.	House of Good Shepherd		Cast-iron sectional heating			0	0		Five sections ruptured
Jan. 16	Burgettstown, Pa.	The Atlas Coal Co.		Water-tube			0	0		Tube rupture
Jan. 16	New Britain, Conn.	School Sacred Heart		Cast-iron sectional heating			0	0		Two sections cracked
Jan. 16	Sapulpa, Okla.	St. Louis & San Francisco R.R.	8:00 a.m.	Locomotive			2	0		Unknown
Jan. 16	Near Skiatook, Okla.	Barnsdall Oil Co.'s Lease					1	1		
Jan. 16	San Antonio, Tex.	Office Bldg. of Mrs. C. Kapman		Cast-iron sectional heating			0	0		Section ruptured
Jan. 17	Pellston, Mich.	Pellston Planing Mill & Lumber Co.					0	0		Blowoff pipe ruptured
Jan. 17	New Orleans, La.	Academy of the Sacred Heart		Cast-iron sectional heating			0	0		Section ruptured
Jan. 17	West Liberty, Ia.	East School	7:10 a.m.	Hot water			0	0	$14,000*	Section ruptured
Jan. 18	Santa Fe, N. M.	New Mexico Penitentiary					0	0		Tube ruptured
Jan. 18	Easton, Pa.	Residence of Lloyd V. Bush		Heating			0	0		
Jan. 19	New York City	116 W. 75th St.		Cast-iron sectional			0	0		Section ruptured
Jan. 20	Sherman, Tex.	Oil Mill of Birge-Forbes Co.					0	0		Tube rupture
Jan. 20	Birmingham, Ala.	Avondale Mills					0	1		Tube ruptured
Jan. 21	Keota, Ia.	Public School		Heating			0	0		
Jan. 21	McKees Rocks, Penn.	The Lockhart Iron & Steel Co.		Water-tube			0	0		Tube rupture
Jan. 21	Lancaster, Penn.	Harry A. Schroyer Greenhouses	6:30 p.m.	Heating			0	0		Leak at seam of old boiler
Jan. 22	Sioux City, Ia.	Armour & Co.					0	0		Tube rupture
Jan. 22	Mabton, Wash.	Washington School	9:00 a.m.	Cast-iron	15		0	0	$175	Low water due to frozen pipe
Jan. 25	Erie, Penn.	Nagle Engine & Boiler Works					0	1		Blowoff failed
Jan. 26	San Francisco, Cal.	1490 Valencia St.	6:30 a.m.	Hot water	60	22x74"	0	0	$2,000	Valve closed causing over pressure
Jan. 26	Near Ligioner, Penn.	Shenango Furnace Co.'s Sawmill	3:00 p.m.	Upright	80	60 hp.	0	4		Sudden injection of cold water
Jan. 26	Hoopeston, Ill.	Iliff-Bruff Chemical Works	2:45 p.m.	Low pressure			1	0		
Jan. 27	New Haven, Conn.	Store & Office Building		Cast-iron sectional			0	0		Section cracked
Jan. 27	Philadelphia, Penn.	John B. Stetson Co.	4:00 a.m.	Water-tube	125	1,000 hp.	0	0	$100	Low water
Jan. 28	Barberton, O.	The Columbia Chemical Co.		Water-tube			0	0		Tube rupture
Jan. 29	Missoula, Mont.	The Bell Telephone Co.	9:00 a.m.	Hot water	10	No. 47	0	0	$150	Outlet from expansion take frozen
Jan. 29	Near Juarez, Mex.	Mexican Central R.R.	p.m.	Locomotive			3	6		
Jan. 29	Missoura, Mont.	J. Brower		Kitchen range			0	0		
Jan. 30	Boston, Mass.	Office Building of Nathan H. Gordon		Cast-iron heating			0	0		Two sections ruptured
Feb. 1	Philadelphia, Penn.	Phila. General Hospital	3:00 a.m.	Water-tube—marine	100	100 hp.	0	0	$160	Low water caused two headers to break
Feb. 1	Princeton, Ind.	L. J. Rotschild's Laundry					0	0		
Feb. 1	Waterbury, Conn.	Southern New England Telephone Co.		Cast-iron heating			0	0		Five sections ruptured
Feb. 1	Slidell, La.	Salmon Brick & Lumber Co.		Water-tube			0	0		Five cast-iron sections ruptured
Feb. 2	Ada, Okla.	Willard School	7:00 a.m.	Cast-iron heating	15	6-section	0	0	$125	Low water; caused by poor circulation
Feb. 2	Providence, R. I.	Wm. B. Bannigan Estate		Cast-iron heating			0	0		Two sections ruptured
Feb. 2	Huntington, W. Va.	Towboat Sam Brown	11:00 a.m.		165		12	0	$30,000	Valve weighting caused overpressure
Feb. 2	New Brunswick, N. J.	Howe Rubber Co.	9:30 a.m.	Return-tubular	70	60"x14'	2	4	$50,000	Overheating around blowoff outlet
Feb. 4	Hazleton, Penn.	Residence of J. R. O'Donnell		Hot water			0	0		
Feb. 4	Hazleton, Penn.	Residence of Mrs. H. McMenamin		Hot water			0	0		
Feb. 4	Pittsburgh, Penn.	Diamond National Bank		Water-tube	100	250 hp.	1	0	$25	Defective tube
Feb. 4	Troy, Ala.	R. B. Chapman's Greenhouses	11:00 p.m.				0	0		Failure of safety valves
Feb. 5	Monroe, La.	Standard Warehouse & Compress Co.					0	1		
Feb. 5	Chicago, Ill.	Three Arts Club	8:45 a.m.	Down draft hot water heating	30	8,000 sq.ft. rad.	1	0	Sections	Two sections failed
Feb. 6	Near Birmingham, Ala.	Seaboard Train No. 12	3:00 p.m.	Locomotive	190		1	1	$200	Flue pulled out on firebox end
Feb. 6	Chicago, Ill.	Delta Kappa Epsiolon Home	4:00 a.m.	Hot water	20		0	0	$250	Piece 6-in. sq. forced out of top of boiler
Feb. 7	Galesburg, Ill.	Galesburg Railway & Light Co.		Water-tube			0	0		Tube ruptured
Feb. 8	Gardner, Mass.	The Standard Oil Co.'s Office					0	0	$2,500	
Feb. 8	So. Chicago, Ill.	By-Products Coke Corporation		Water-tube			0	0		Six cast-iron headers ruptured
Feb. 8	Boston, Mass.	Massachusetts Homeopathic Hospita.		Cast-iron sectional	15	12 section	0	0	$150	Low water
Feb. 8	Lexington, Mo.	Leonard Coen's Greenhouse					0	0		Cold water injected into hot boiler
Feb. 9	Boston, Mass.	Charles St. Jail		Hot water			0	0		
Feb. 10	Fargo, N. D.	Apartment Bldg. of D. Burrell		Cast-iron heating			0	0		Two sections ruptured
Feb. 10	Near Mardela Springs, Md.	Graham & Hurley Sawmill	11:30 a.m.	Return-tubular	100	35 hp.	5	3		Old boiler, over pressure
Feb. 12	Theresa, N. Y.	Methodist Church		Heating			0	0		Flue burst
Feb. 12	New York City, N. Y.	New York Steam Co. (59th St. & E. River)		Water-tube			0	0		Two cast-iron headers ruptured
Feb. 12	Beaumont, Tex.	John F. Gilbert Office Building		Cast-iron heating			0	0		Section ruptured
Feb. 13	Vicksburg, Miss.	Yazoo & Sunflower Trans. Co. Steamer		Scotch marine			0	0		
Feb. 13	New York City, N. Y.	Taper Novelty Mfg. Co. (225 E. 36th St.)		Heating			0	0		
Feb. 14	Ridgefield Park, N. J.	Arcade Theatre		Cast-iron heating			0	0		Two sections ruptured
Feb. 14	Trenton, N. J.	Rider-Moore-Stewart Business College	2:00 a.m.	Heating	5	2,000 sq.ft.	0	1		Low water caused by defective air valve
Feb. 14	Slatington, Penn.	Residence of John Reber		Heating			0	0		
Feb. 14	Rome, Ga.	Anchor Duck Mills		Water-tube			0	0		Nine cast-iron headers ruptured
Feb. 15	Harrison, N. J.	236 Harrison Ave.		Kitchen range			0	0		
Feb. 15	Walden, N. Y.	Private residence		Kitchen range			0	2		
Feb. 15	Philadelphia, Pa.	2205 Bolton St. (Mrs. H. Jones)	7:00 a.m.	Heating			0	4	$50	Frozen water supply pipe
Feb. 15	Cushing, Okla.	Chanute Refining Co.	3:00 a.m.	Return-tubular	100	150 hp.	0	0	$500	Scale dropping burned hole in boiler
Feb. 15	Detroit, Mich.	Detroit City Gas Co.		Water-tube			0	0		Tube ruptured
Feb. 15	Parkville, Mo.	Park College		Heating			0	0		Section ruptured
Feb. 15	Philadelphia, Pa.	2205 Bolton St.					0	4		

* Caused by fire following explosion.

BOILER EXPLOSIONS, JULY, 1915, TO JULY, 1916—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Feb. 17	Hazleton, Penn.	St. Stanislaus Polish School		Heating			0	0		
Feb. 17	Marquette, Mich.	State House of Correction & Branch Prison					0	0		Tube ruptured
Feb. 17	Brooklyn, N. Y.	1719 79th St.		Heating			0	0		
Feb. 18	Altoona, Pa.	Car Shop Boiler House					0	1		
Feb. 18	Greenville, Miss.	Delta Oil Co.	2:20 a.m.	Water-tube	110		1	1	$150	Tube ruptured
Feb. 19	Near Overbrook, N. J.	Erie R.R.		Locomotive			0	5		Flue collapsed
Feb. 19	Stevensville, Md.	Stevensville High School		Heating			0	0		
Feb. 21	Bridgeport, Conn.	Home of Jas. Murnuck		Water back of range			0	0		
Feb. 21	Zanesville, O.	Mark Mfg. Co.		Water-tube			0	0		Two tubes ruptured
Feb. 21	St. Louis, Mo.	American Paper Products Co.	6:00 a.m.				1	0	$300	Blowoff tank failed
Feb. 23	Kewanee, Ill.	Kewanee Boiler Co.	8:30 a.m.	Horizontal-tubular	110	72″x18	0	1	$20	Cracked cast-iron fitting on blowoff
Feb. 24	Winona, Mich.	Winona Copper Co.		Water-tube	165	268 hp.	0	0		Tube ruptured
Feb. 24	Near Brooklyn, Miss.	Martin & Gay Lumber Co.	10:30 a.m.		120	45 hp.	1	3		Low water
Feb. 26	El Dorado, Ark.	Residence of R. N. Garrett		Cast-iron heating			0	0		Section ruptured
Feb. 27	Waukesha, Wis.	Waukesha Gas & Electric Co.	4:30 a.m.	Water-tube	150	260 hp.	0	0	$500	Low water
Feb. 27	Philadelphia, Penn.	Penn Hospital	5:00 a.m.	Water tube	100	100 hp.	0	1	$300	Tube ruptured
Feb. 28	Near Greenville, S. C.	Conestee Mills	6:40 p.m.	Horizontal return tubular	110	16x66	2	6	$20,000	Hidden lap-joint crack
Feb. 29	Near Moscow, Ia.	Lee Smith Farm	10:30 a.m.	Tractor	110	16 hp.	0	0	$800	Weak boiler
Mar. 1	Hollis, N. H.	Worcester's Mill					0	2		
Mar. 1	Near Orrville, Ala.	Pine-Belt Lumber Co.'s R.R.	Noon	Locomotive	130	36 ton	0	3	$1,500	Weak stay bolts
Mar. 2	Easton, Pa.	Pennsylvania Utilities Co.	11:00 p.m.	Water tube	200	400 hp.	2	1		Unknown
Mar. 3	Wilmington, Del.	Home of Albert Sergeant		Heating			0	0		
Mar. 3	Augusta, Ga.	Plazo Hotel		Cast-iron heating			0	0		Two sections cracked
Mar. 3	Ireland, W. Va.	Ireland Lumber Co.	11:a.m.		140	12′x48″	4	2		Low water
Mar. 3	Near Cuba, Ill.	Ed. Bishop's Farm					0	0		Low water, clogged valve to gage glass
Mar. 4	Mt. Hope, W. Va.	Office Bldg. of Glen Jean Insur. Agency	9:00 a.m.	Cast-iron heating	15	5 sections	0	0		Five sections ruptured
Mar. 6	Mayville, Wis.	Northwestern Iron Co.		Locomotive type			0	0		Crown sheet collapsed
Mar. 6	Newberry, S. C.	Newberry Cotton Mills		Water-tube			0	0		Tube ruptured
Mar. 9	Canon City, Colo.	Diamond Fire Brick Co.					0	0		Blowoff pipe failed
Mar. 9	Near Del Rio, Tex.	Southern Pacific R.R.	9:00 a.m.	Locomotive	200	80″ diam.	1	1	$9,100	Low water
Mar. 10	Hazleton, Penn.	Home of John Meneth		Kitchen			0	0		
Mar. 10	Branford, Conn.	Brushy Plain School		Cast-iron heating						Section cracked
Mar. 10	N. Tonawanda, N. Y.	General Electric Power House		Portable			0	0	$3,000	
Mar. 11	Near Ohio City, O.	M. J. Lynch & Sons Well-Drilling		Locomotive type	125	25 hp.	0	0		Failure of crown sheet
Mar. 12	Fairfield, Ala.	The Barrett Co.	9:00 p.m.	Vertical water tube	140	250 hp.	0	1		Tube failure
Mar. 12	Cudahy, Wis.	Federal Rubber Mfg. Co.		Water tube						Tube ruptured
Mar. 13	Pikeville, Ky.	Pikeville Planing Mill & Supply Co.					4	2		Injection of cold water into boiler
Mar. 13	Milwaukee, Wis.	Residence of Mrs. Edw. Shuster		Heating			0	0	$2,500	
Mar. 13	Milwaukee, Wis.	947 Summit Ave.	3:00 p.m.	Cast-iron heating		1,925 sq.ft.	0	0	$200	Low water—circulating lines shut off
Mar. 14	Wichita, Kan.	Traction engine					1	0		
Mar. 14	Hoboken, N. J.	207 Eleventh St.		Heating			0	0		
Mar. 15	Near Pittsfield, Mass.	Boston & Albany R.R.		Locomotive			0	3		Crown sheet dropped
Mar. 15	State Line, Mass.	Boston & Albany Freight Train	1:30 a.m.	Locomotive	200		1	2	Boiler	Firebox crown sheet dropped
Mar. 18	Woburn, Mass.	Dept. Store of Mary E. McGrath		Cast-iron sectional			0	0		Four sections ruptured
Mar. 18	Danbury, Conn.	Danbury Mfg. Co.	7:00 a.m.	Cast-iron sectional	20		0	0	$150	Low water
Mar. 19	Somerville, N. J.	Residence of Paul Gallichet		Heating			0	0		
Mar. 20	East St. Louis, Ill.	Armour & Co.		Water-tube			0	0		Cast-iron header ruptured
Mar. 20	Milwaukee, Wis.	The Falk Co.	5:30 p.m.	Vertical water-tube	140	300 hp.	0	0		Several tubes failed
Mar. 21	Near South Bloomingville, O.	Sawmill	11:00 a.m.		80	10 hp.	0	3	$200	Unknown
Mar. 21	Hartford, Conn.	Office Bldg. of Isidore Wise					0	0		Section ruptured
Mar. 24	Batesville, S. C.	Prospect Mills	5:30 a.m.				0	3	$4,000	Hidden lap seam crack
Mar. 24	Winslow, Ariz.	Santa Fe R.R.		Locomotive			3	0		
Mar. 24	Providence, R. I.	Estate of Wm. B. Bannigan		Cast-iron sectional			0	0		
Mar. 24	Zanesville, O.	H. H. Sturtevant & Co. Dept. Store		Cast-iron heating			0	0		Section ruptured
Mar. 25	New York City, N. Y.	General Chemical Co.					0	1		Tube burst
Mar. 25	Near Peter Creek, Pikeville, Ky.	Manuel Riddle Grist Mill					5	12		
Mar. 27	Easthampton, Mass.	Daniel Dwyer Tonsorial Parlor		Hot water			0	0		
Mar. 28	Sipsey, Ala.	Maryland Coal & Coke Co.					0	1		Blowoff pipe failed
Mar. 29	Near Houston, Tenn.	Godwin & Fall Sawmill	7:30 a.m.				3	2		Old boiler had been condemned
Mar. 29	Chattanooga, Tenn.	Durham Coal Mines					0	1		
Mar. 29	St. Louis, Mo.	Polar Wave Ice & Fuel Co.	11:10 a.m.	Water-tube	120	350 hp.	1	5		Tube ruptured
Apr. 1	Near North Mountain, W. Va.	Baltimore & Ohio R.R.	4:00 a.m.	Locomotive	193	78″	1	2	$1,800	Low water
Apr. 2	Wellsburg, W. Va.	Wellsburg Ice & Storage Co.		Scotch marine			0	0		Corrugated furnace collasped
Apr. 3	Near Brownwood, Tex.	Santa Fe R.R.		Locomotive			0	3		
Apr. 3	Council Bluffs, Ia.	The Bloomer Cold Storage Co.					0	0		
Apr. 4	Mortimer, N. C.	Wm. Ritter Lumber Co.	Noon				1	0		
Apr. 5	Brookline, Mass.	The Country Club		Cast-iron heating			0	0		Section ruptured
Apr. 6	Near Bedford, Ind.	Chicago, Indianapolis & Louisville R.R.	6:15 a.m.	Locomotive			0	2		Low water
Apr. 7	High Point, N. C.	High Point Steam Laundry	1:00 p.m.			25 hp.	1	1		Putting cold water into dry boiler
Apr. 12	Rochester, N. Y.	Mosely & Motley Milling Co.		Cast-iron heating			0	0		Five sections ruptured
Apr. 13	Geneva, N. Y.	Empire Gas & Electric Co.	4:00 p.m.	Water-tube	150	500 hp.	1	2	$50	Unknown
Apr. 13	Louisville, Ky.	Southern Veneer Mfg. Co.	9:00 a.m.	Horizontal tubular	100	150 hp.	0	0	$250	Boiler tube blew out
Apr. 14	Providence, R. I.	The Butler Exchange Co.		Water-tube	85 lb.	125 hp.	0	3	$500	Tube ruptured
Apr. 15	Hoffman, Okla.	Missouri, Oklahoma & Gulf R.R.		Locomotive			3	4		Cold water in dry, hot boiler
Apr. 15	Bellefontaine, O.	Hotel Ingalls	7:30 p.m.				0	0	$200	Accumulation of coal gas in firebox
Apr. 17	New Brighton, Penn.	Standard Sanitary Mfg. Co.		Water-tube			0	0		Tube ruptured
Apr. 20	Near Spencer, W. Va.	South Penn. Oil Co.	2:00 p.m.				1	0		Old boiler
Apr. 23	Morganza, Penn.	Pennsylvania Training School		Water-tube			0	0		10 sections ruptured
Apr. 23	Humble, Tex.	Hancock & West Lease					0	1		Unknown

BOILER EXPLOSIONS, JULY, 1915, TO JULY, 1916—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Apr. 25	South Omaha, Neb.	Swift & Co.		Water-tube			0	6		Cast-iron mud drum exploded
Apr. 26	Hazleton, Penn.	Hazleton Steam Heating Co.					0	0		Flue burst
Apr. 28	Philadelphia, Penn.	Samaritan Hospital		Water-tube		100 hp.	0	0	$500	Low water
Apr. 28	Philadelphia, Penn.	Temple University	4:00 a.m.	Water-tube	90	100 hp.	0	0	$90	Unknown
May 8	Kokomo, Ind.	Well-Drilling Outfit		Vertical	120		0	2	$1,800	Unknown
May 10	Stamford, Conn.	Stamford Rolling Mill					0	2		
May 10	Pensacola, Fla.	Newport Turpentine Co.	10:00 a.m.	Vertical tubular	100	40 hp.	0	9		Failure of pop safety valve
May 13	Biddeford, Me.	Livingston Estate					0	0	$400	
May 13	Near Hickory, N. C.	Sawmill of Frank Fulbright					0	3		
May 17	Atlanta, Ga.	Georgia Fibre Corporation					0	3		
May 18	Minneapolis, Minn.	Williams Bros.		Vertical	55	4'x18"	1	3	$250	Low water
May 24	Anderson, Ind.	Wagoman Bakery	3:30 a.m.	Locomotive type	110	25 hp.	0	0	$200	Low water
May 25	East Brady, Penn.	James Lumber Co.'s Sawmill	4:00 p.m.	Locomotive			3	3		
May 26	Near Belfast, N. Y.	Erie R.R.	7:15 a.m.					1		Low water
May 29	Humble, Tex.	Oil Field of Guy Mennis	3:00 a.m.	Portable	85		1	2		Ruptured while being tested with air pressure
May 30	St. Louis, Mo.	Barrett Roofing Co.	2:20 p.m.				0	3		
May 30	Beaumont, Tex.	Electric-light Plant	12:30 p.m.			70 hp.	5	3		Low water
June 3	Brewton, Ala.	T. R. Miller Mill Co.	7:30 p.m.				1	2		
June 9	Keeling, Va.	Wilkinson's Farm					1	2		
June 14	Near Mt. Erie, Ill.	Sawmill		Water-tube	200	400 hp.	1	2		Tube pulled out
June 14	Easton, Penn.	Penn. Utilities Co.					0	1		Boiler pipe burst
June 22	Glens Falls, N. Y.	Fenimore Mill					0	1		
June 25	Monkton Ridge, Vt.	Amer. Kaolin Co.					0	1		
June 30	Seattle, Wash.	Fire Station No. 21	3:05 p.m.	Locomotive			0	1		
July 4	Near Sweeney, S. D.	Missouri, Kansas & Texas R.R.					1	2		
July 4	Near Lever, Ky.	Kanova Oil Co.					0	3		
July 7	Humble, Tex.						0	1		Water feed pipe broke
July 10	Potosi, Wis.	Potosi Brewing Co.					0	0		
July 12	Near Collins, Miss.	Sawmill	3:30 p.m.	Locomotive type			0	1		Low water
July 15	Near Dawson, Ill.	Traction Engine	8:00 a.m.				0	1		
July 15	Near Barbourville, Ky.	Bingham-Hammons Mill	10:00 a.m.		125	30 hp.	2	1	$1,000	Unknown
July 15	Eagle Rock, N. C.	Sawmill			200		1	2		Valve accidentally shut off
July 21	Near Merrifield, Minn.	Wright-Barnes-Olson Lath Mill					2	1		Tube blew out
July 24	Lima, O.	Western Ohio R.R. Shops	8:30 p.m.	Water-tube			1	0		
July 26	Beebe, Ark.	McCord's Mill					1	5	$1,400	Unknown
July 28	Oldtown, N. C.	Oldtown Lumber Co.	Noon		100	25 hp.	1	1	$5,000	
July 28	Brooklyn, N. Y.	Riggi Bros.	10:00 a.m.		100		1	3		
July 31	Gretna, Neb.	Rithal Farm								
	Total number 347						Total 158	400	$498,285	

Worm Gearing Stuck

By E. C. Parham

One advantage that a worm-gear construction has over an ordinary spur-gear construction is that, although it is very easy to turn the wheel by means of the worm, normally it is impossible to turn the worm by means of the wheel. This feature is particularly desirable on motor-driven hoists, because it simplifies braking. On a gear-driven hoist that must handle heavy loads, it is necessary to provide a brake that is sufficiently effective to hold the whole hook load against the tendency to lower when the operating current is thrown off. On a worm-gear hoist, however, the resistance of the gearing is sufficient to hold the load against lowering and the electric brake need be only strong enough to stop the armature when the current is interrupted. Most trouble experienced with the worm-and-wheel drive can be traced to lack of attention in the matter of lubrication or to poor alignment that prevents the worm threads and the wheel teeth from meshing properly. In such cases there may occur cutting that converts a very easy running drive into a very hard running one.

A crane operator complained that the motor was getting so weak from age that it could no longer handle the load—which was usually a ladle of hot metal. The motor was immediately tested and found to be electrically sound; also it was carefully inspected for low bearings, loose parts, bent armature shaft and clinging brake shoe, but no irregular condition could be found. The crane constructor was then appealed to and an inspector determined that, because no grease had been put into the gear case since a change in crane operators a month before, the worm and gear had begun to cut and bind. It was necessary to replace them before satisfactory operation of the crane could be secured.

In another instance, a motor-driven reciprocating water pump sometimes would start alone and at other times would start only when helped by hand. As the motor was automatically controlled, the automatic feature could not be utilized to full advantage, because there was danger of the motor being stalled and injured if no one happened to be around. Of course all trouble was attributed to the electrical equipment, and an inspector was called. He determined that the trouble was due to poor alignment between the motor and the connected load. The worm threads had begun to cut the wheel-teeth, but in this case the damage was not so bad but that the perfecting of the alignment would eliminate the trouble.

There seems to be an unwritten law that if trouble of any kind occurs on an installation that involves electrical apparatus, the cause must be electrical. In both instances cited, the motor was suspected and an electrical man was called; in neither instance was the motor at fault.

[A worm gear that is cutting may be remedied by putting powdered sulphur in the gear case with the oil, and after the gear has run for two or three days clean out the case and renew the oil.—Editor.]

Economo Feed-Water Purifier

It is not uncommon for engineers to speak of feed water as being hard or soft as the case may be. The substances that make water hard are salts of lime, magnesia and iron, which are held in solution in cold water and are precipitated when the water is brought to the boiling point. Hardness, due to bicarbonates, which overflows *H*, which discharge the water into the boiler. A check valve is connected in the pipe *G*, likewise in the pipes *J* and *K*. A blowoff pipe is provided at *L*.

The principle of operation is that as the piping and the purifier are exposed to the temperature of the steam and water at boiler pressure, the water in making its passage through the pipe *B* is so highly heated that its scale-forming elements are precipitated in the lower

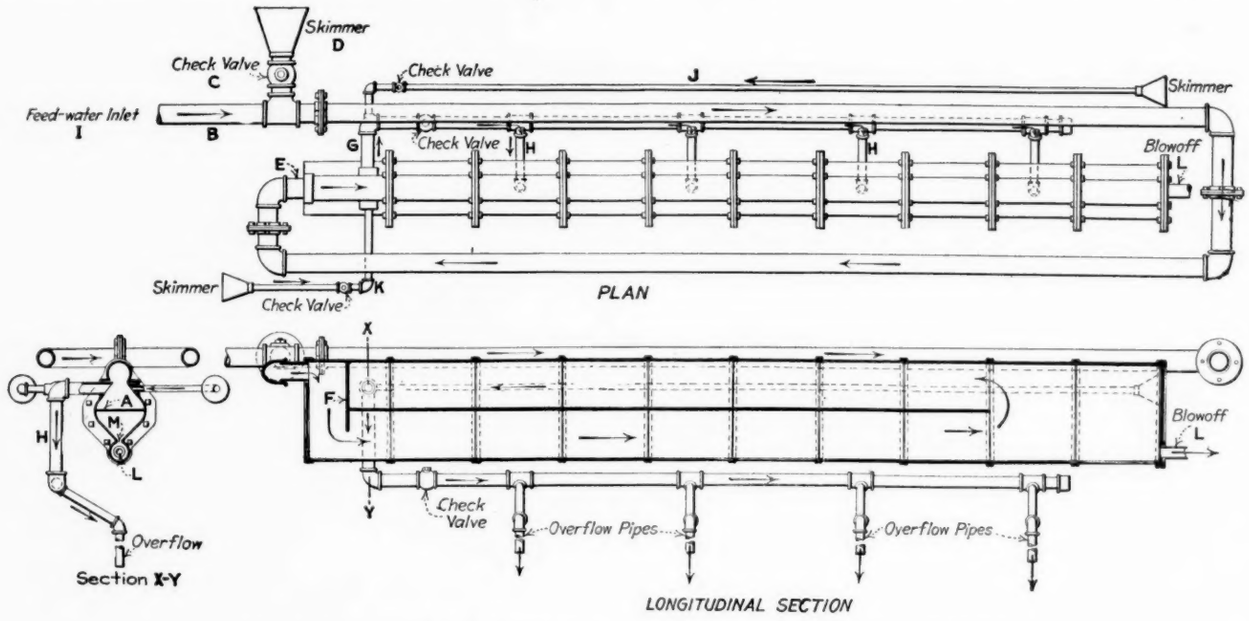


FIG. 1. PLAN AND LONGITUDINAL SECTIONAL VIEW OF THE PURIFIER

upon boiling the water is lessened, is designated as temporary hardness; that which is not removed by boiling is termed permanent hardness.

That the so-called permanently hard water may be so treated as to be suitable for boiler feed without the losses occasioned by the formation of scale, by the scale-forming elements being removed, has led the Boiler Water Purifier Co., Inc., 804 Bellevue Court Building, Philadelphia, Penn., to perfect the "Economo" boiler-water purifier, which is located inside the boiler and purifies the entering feed water without the aid of any kind of compound or chemicals. It can be applied to both water-tube and return-tubular boilers.

A plan and a longitudinal sectional view of the purifier are shown in Fig. 1. The body is made in flanged sections the faces of which are machined, and the sections are bolted together without gaskets between them. An end sectional view of the purifier is shown in the section *X* — *Y*, the diaphragm *A* dividing the section into an upper and a lower chamber.

Referring to the plan and sectional views, the feed water enters the pipe *B*, to which is fitted a tee for connection with the check valve *C* and skimmer *D*, the purpose of which will be explained later. Feed water after passing twice the length of the purifier enters the head end at *E* to the end chamber, which is fitted with a baffle *F* that forms the closed end of the upper chamber, and directs the entering water to the lower chamber of the purifier. The course of the water is shown by the arrows, and after flowing in a reverse direction toward the front end of the upper chamber, it passes out of the purifier through the pipe *G*; which is fitted with the chamber, from which they settle into the sludge chamber *M*, whence they are blown out through the blowoff *L*.

The skimmers are so arranged that they are but partly submerged and the check valve is close against the open end of their connection. As a result, when the blowoff valve is opened water and steam are forced from the boiler into the skimmers, and because of the reduced pressure inside of the purifier, the check valves are forced from their seats.

Water flowing through the pipe *B* washes the sediment out of the sludge chamber through the blowoff, and that

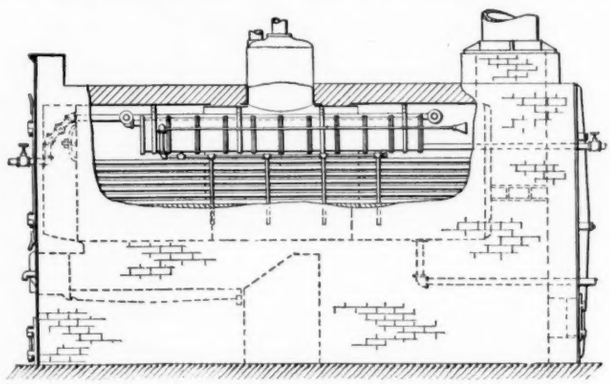


FIG. 2. PURIFIER IN A RETURN-TUBULAR BOILER

coming in through the two smaller skimmers washes whatever may have collected in the upper chamber of the purifier. As soon as the blowoff valve is closed, the pressure builds up in the purifier and the check valve closes; the flow through the purifier is then as before.

Editorials

Single-Phase Power Production

As long as alternating current was used for lighting only, the single-phase system gave complete satisfaction. The simplicity of the generating, transmitting and receiving apparatus makes this system very desirable. When the demand for alternating current for power purposes came about, a new difficulty arose in the application of the alternating-current system; namely, to get a motor that would be self-starting without some special starting device. This task was accomplished with the development of the polyphase system, but where a lighting load or other single-phase devices are supplied from a polyphase system, it has always been a problem to keep the load properly balanced. This did not offer any very serious difficulty as long as the devices were small; they could usually be divided up between the different phases to maintain a fairly balanced condition. However, when the demand arose for a large amount of single-phase power to be furnished from polyphase systems such as electric furnaces and single-phase trunk-line railway electrification, it became apparent that some means must be devised to convert the polyphase system into a single-phase and at the same time maintain the voltage and current balanced in the former.

The first device for changing the phase of an alternating-current circuit employed an inductor and condenser. This was used to convert single-phase circuits into polyphase for starting induction motors, but it was not very satisfactory and was limited to small sizes.

For many years a motor-generator set was the only device that satisfactorily solved the problem of converting polyphase alternating-current into single-phase, or vice versa, as far as phase conversion is concerned. This is still the only means whereby large amounts of polyphase alternating currents of one frequency may be changed into single-phase at a different frequency. Where 25-cycle single-phase railway electrifications are to be supplied from a 60-cycle polyphase system, a motor-generator set must be used. The only objection to this method of phase conversion is that two machines are required and that each must be equal in capacity to the single-phase load, consequently the cost of the machines must be high.

The polyphase induction motor is inherently a phase converter, although it has been utilized to only a limited extent until recently. Among the most notable installations of this kind are the polyphase converting locomotives used on the Norfolk and Western Railroad. In this instance the converters are used to change single-phase into three-phase alternating current. When the operation is reversed with this type of phase converter—that is, changing polyphase to single-phase—it becomes necessary to provide some means to maintain the voltage and current balance. Especially is this true when the single-phase load is shifting from one phase to the other of the polyphase system. This may be done by an auxiliary synchronous generator driven from the converter shaft; the set then is known as a synchronous phase balancer and by the use of automatic regulators can be made to maintain the current and voltage balance in the polyphase system supplying the single-phase load, irrespective of how the load may shift from one phase to the other.

The theory of this scheme was worked out in 1911 by E. F. W. Alexanderson, and presented in a paper before the A. I. E. E., but it remained until recently for a practical application to be made of this set of machines; and from the reported successful operation of the installation it appears that Mr. Alexanderson and his associates have established another milestone in the electrical industry.

On another page in this issue is published an abstract from a paper by Mr. Alexanderson and D. H. Hill, on "Single-Phase Power Production." The paper is a masterly treatment of this subject both as to the way this class of electric service may be obtained and on the different types of phase-converting apparatus and their operating characteristics.

What the Power-Plant Owner Really Wants

The net requirements of the modern power-plant owner who uses electricity, steam or hot water in his business are very simple. Expressed in a few words, he wants first-class service at the lowest feasible cost. This is the basis of the operating engineer's usefulness, and when the engineer cannot perform this service as well as an outside organization, the outcome is sooner or later a change in position or the abandonment of "home-made" energy.

At the Pittsfield, Mass., convention of the New England section of the National Electric Light Association, reported in last week's issue, nearly an entire session was devoted to the discussion of the difficulties of securing large power business, continuing in a measure the excellent program upon that subject which was such a feature of the Kineo, Me., convention last year. Instead of the minor chords of 1915, however, the chorus from the Berkshires was pitched this year in a major key, and the papers drew forth not a little congratulation from the central-station men because of the manner in which they set forth the downfall of many a privately-owned plant.

Now if the operating engineer has anything for which to be thankful, it is for occasions like this, where the pitfalls into which the plant owner and his engineer too often have stumbled in times past are set forth so that he who runs may read. Only there is no need for running as yet, the duty of the present hour being merely to take one's belt up a notch or two and consider a very significant statement that appeared in the paper of David Elwell, of the consulting engineering firm of Lockwood, Greene & Company, Boston, on "The Use of Central Station Power by Large Power Consumers." This statement says: "Studies of the cost of purchased and privately generated electric power for industrial plants of good size made by the concern with which I am associated indicate that power rates are often based on the private plant's

probable power cost rather than the central station's; that is, the latter charges all that the market will stand." And again, in a paper by Warren B. Lewis, consulting engineer, Providence, R. I., appear these sentences: "It is rare to find good technical direction for power-plant operations, except in those industries where the cost of power is of first importance. It is hardly to be expected that in an industry where the cost of power represents but a small percentage of the value of the business done there should be attached to it the importance which it deserves. Furthermore, it is not often that an isolated plant can afford to employ the kind of supervision that is really needed. It requires a peculiar kind of service to get the very best efficiency out of a plant that is made up of a great mixture of machinery and piping systems, and it is doubtful whether that service can be supplied except from a central organization which can divide its time, and hence its expense, over a number of plants."

Whether deserved or undeserved, these statements are a challenge to the professional ability of every ambitious engineer. What is he going to do about it? The answer is clear. It is up to him to run his plant so efficiently that no outsider can come in and take advantage of his inefficiency, offering the owner a lower rate for total service than present costs—a rate, by the way, that may be far above the possible costs with top-notch engineering administration. Why should a central station offer to operate a plant much below the present cost of the service? It is often necessary only to guarantee some saving to get the business, and the published rates for energy are only incidental to the contract in many cases. It is for the engineer to pit himself against outside brains and to see to it that no reasonable fault can be found with his service from the efficiency standpoint. Then if the outside concern can afford to make a rate lower than can be realized by isolated operation, the logical step is for the owner to avail himself of such service; and if the engineer refuses to coöperate, he is only butting his head against a solid wall.

Thirteen Months' Report of Boiler Failures

As shown by the tabulation, pages 653 to 657, the total number of boiler failures reported, including blowoff pipes and a few locomotives, chiefly those used for industrial purposes, was three hundred and forty-seven for the period from July 1, 1915, to July 31, 1916. There are known to have been one hundred and fifty-eight killed and four hundred more or less seriously injured.

The monetary loss, while not even approximated in the majority of cases, totaled about five hundred thousand dollars, some of the larger items being due to fires following, but as a direct result of the boiler failures. The domestic cast-iron water and steam heaters loom prominent in the list, with about ninety failures to their credit. As usual, the much-abused portable and sawmill boilers have taken their full toll of life and limb.

The causes assigned, while not authoritative, were taken from the best obtainable information, and give a total of sixty failures of cast-iron headers, forty ruptured tubes, thirty-seven low water and sixteen overpressure.

While there seems to be a decided improvement in the construction and operation of medium- and high-pressure boilers the same cannot be said of those designed for low pressure, chiefly for heating purposes; partly no doubt because it is presumed that the pressure will always be low, but when the relief valve fails, the increasing pressure is sure to disrupt the boiler at the weakest point. A liberal margin of safety and strict attention to means of relieving overpressure seem to be the reasonable precautions for avoiding disaster.

Smoke-Abatement Week in Pittsburgh

"It can be done!"

This is Pittsburgh's slogan, heard many times during its Smoke-Abatement Week, October twenty-second to twenty-eighth. Peculiarly, the atmosphere during the week was of that kind which causes a stranger to lose his way because all landmarks more than a short distance are hidden behind the haze of smoke and fog.

Watching the progress of smoke abatement, as we do, we were indeed pleased to observe the large attendance at the dinners, luncheons and meetings held throughout the week. It was evidence that the plant owners and engineers are actively interested in a movement which, besides effecting enormous savings of an engineering nature, will do inestimable good toward promoting lower living costs and public health.

The meeting of engineers and manufacturers at the Chamber of Commerce rooms on Monday afternoon was to talk over the advisability of setting a definite date after which the Bureau of Smoke Regulation would begin suit for violation of the smoke ordinance. Those familiar with conditions will recall that Pittsburgh, unlike most cities, has not during the past two or more years sued offenders, but has relied solely on moral suasion and appeals to civic pride.

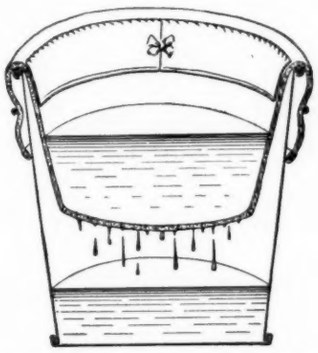
Those who presented figures showing what they had spent in equipment, such as stokers and boiler-room improvement generally, seemed to charge the expenditures to smoke abatement. They appeared to have forgotten that with improvements made there also followed more economical results and, in most cases, increased output without the purchase of new boilers, as would have been necessary in many plants if old methods had been followed. It does not seem equitable—in fact, it is false—to charge to smoke-abatement purposes solely, expenditures that net results in high returns on investments. The agitation for less smoke may, and in nearly all cases probably does, prompt the investment, but the engineering department properly should credit itself with the gains which, when interpreted, show what it has been worth to abate smoke.

This side of the question was forcefully emphasized by Osborne Monnett, former chief smoke inspector for Chicago, who in presenting data on Chicago, showed in one column the amount of the investment in each of a number of plants, and in another the yearly saving actually made on the investment. For investments in amounts up to one thousand dollars the yearly savings ranged from three to eighteen times the outlay. The figures, together with other data given during the week, will be published later in *Power*. "Careful estimating," said Mr. Monnett, "shows that while Chicago spends approximately forty thousand dollars a year on smoke abatement, there are eighteen million tons of coal per year saved thereby."

Correspondence

Oil Filter for a Small Plant

A tin can and a felt hat combined, as shown in the illustration, make a first-rate and inexpensive filter for oil, in a plant that does not justify the purchase of an expensive



OIL FILTERED THROUGH A FELT HAT

apparatus. If there are holes in the top of the hat, pieces of felt (taken from the brim) can be stitched over them.

Brooklyn, N. Y. JAN SPAANDER.

Personality and Success

The editorial, "The Young Engineer's Outlook," in the issue of Oct. 10, was read with much interest and heartily approved.

As an instructor in engineering I frequently try to impress students with the truth that their success is largely dependent on their personality. To make this concrete, I put it this way: "Your ultimate success will depend more upon your table manners than on your technical ability." This sounds strange to men completing a university engineering course and commands attention at once, for technical subjects are given great weight in an engineering school while table manners are entirely ignored. The explanation then follows that technical ability is necessary to secure an entrance into the profession and during the years of subordination engineering ability alone determines progress; but there comes a day when the able subordinate is considered for advancement to a first line position and the "boss" invites him out for lunch or home to dinner. Good table manners and social ability then indicate fitness for meeting men, for representing the employer in public and the consequent advancement. Crude violations of social conventions can only result in his elimination as a candidate for the higher positions, for they all require the ability to be an acceptable companion on all sorts of occasions.

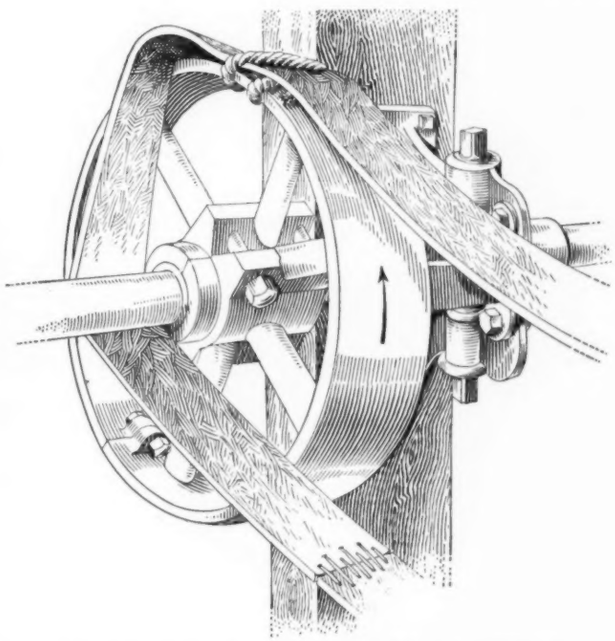
So with a young man starting life as a power-plant engineer, the ultimate degree of his success will depend on his personality. It goes without saying that he must be a good engineer, but being a good engineer will only take him half way; he must be a fine man as well and so conspicuously fine a man that people will talk about him.

To accomplish this it will be necessary for him to develop all his good points and acquire new ones and to subordinate all traits that are in any way disagreeable. Some of the things to cultivate are good carriage, cleanliness and neatness, cheerful smile, good language, even temper and unfailing courtesy. With these habits well developed and all contrary tendencies rigidly suppressed, the young engineer may work, assured that he will not only live a useful life, but that its usefulness will be concretely recognized. G. W. MUNRO.

La Fayette, Ind.

Putting Belts on Pulleys

To put a heavy belt on a pulley, first pull the belt over the pulling side of the driving pulley, wrap a rope around the pulley rim and over the belt where it rests on the pulley face; pull the ends of the rope from under the rim and pass them over the face of the pulley, between it and the belt, the ends pointing in opposite directions. The power may then be thrown on, and the belt will clamp the ends of the rope and both will be pulled



A SAFE WAY TO HOLD A BELT TO A PULLEY

along with the pulley. The rope will release itself and drop off as soon as the belt is on.

This may be an old idea, but it is a safe and sure method of putting on belts. There is one precaution that should be observed; do not use too long a rope as it may become entangled. As shown in the illustration, the ends should not project beyond the face of the pulley.

Monticello, N. Y. ARTHUR AVERY.

Belt Speed for Best Economy is generally between 4,000 and 5,000 ft. per min.

Efficiency of Unsymmetrical Riveted Joints

In the Aug. 8 issue R. N. Blackburn criticizes the conventional approximations of the strength of riveted boiler joints, especially the so-called unsymmetrical ones, and the butt joint with straps of equal width is advanced as being proof against bending stresses.

To a few of the statements in this article I wish to take exception, especially that concerning butt seams

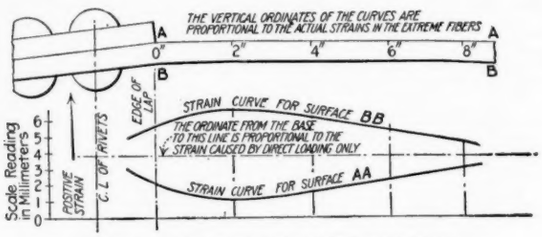

THE VERTICAL ORDINATES OF THE CURVES ARE PROPORTIONAL TO THE ACTUAL STRAINS IN THE EXTREME FIBERS
A
B
0"
2"
4"
6"
8"
EDGE OF LAP
STRAIN CURVE FOR SURFACE BB
THE ORDINATE FROM THE BASE TO THIS LINE IS PROPORTIONAL TO THE STRAIN CAUSED BY DIRECT LOADING ONLY
STRAIN CURVE FOR SURFACE AA
Scale Reading in Millimeters
POSITIVE STRAIN
C. OF RIVETS

FIG. 1. JOINT PROPERLY FORMED

with straps of equal width as being the only type of joint in which no bending stresses are produced. This is a little extravagant, and a greatly exaggerated view is taken by him of the evils of bending stresses due to unsymmetric design of joints with unequal straps, as shown in the examples in the A. S. M. E. Boiler Code.

It is well recognized that bending stresses in the shells of boilers somewhere near or in longitudinal joints that breathe, are due more to imperfect forming of the difficulties of manufacture are not eliminated—chiefly the difficulty of producing, by the ordinary process of rolling, a shell that is truly round throughout, the imperfections in this respect being always in the ends of the plate which go into the joint. There is little doubt that the real cause of cracking of many lap joints, was due more to this out-of-roundness near the joint and improper forming of the laps, producing local initial stress when the internal pressure caused the contour of the shell to become a perfect circle, than to the unsymmetrical pull in the plates, which admittedly is inherent in lap joints, though not necessarily the cause of excessive stresses.

In this connection it may be well to point out an omission in the quotation by Mr. Blackburn from the description of the tensometer tests of double-riveted lap joints, in *Power*, Apr. 15, 1913, where he states that the maximum stress was found to be nearly four times that produced by the direct pull. It should be remembered that this was found in a lap joint in which the ends were not previously bent. In the case where the ends were properly formed, Fig. 1 (as they should be for all lap joints of round shells subject to internal pressure), the strain curves varied only slightly from the line representing the effect of the direct load.

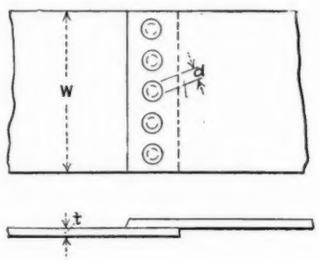


TABLE 1. SINGLE-RIVETED LAP JOINTS

Test No	Materials Rivet Holes Drilled or Punched	Dimensions W., In.	T., In.	D., In.	Net Section, Sq.In.	Shear Area, Sq.In.	Actual Tensile Strength of Plate, Lb. per Sq.In.	Assumed for Calculation Shearing Strength of Rivets, Lb. per Sq.In.	Calculated Efficiency, A.S.M.E. Code, per Cent.	Tested Efficiency, per Cent.	emarks
36	Iron plate, Iron rivets, Holes punched	10.00	0.252	0.695	1.63	1.92	47,925	38,000	60.3	61.4	Shear of 4 rivets, Tore corner at 1 rivet
41	Iron plate, Steel rivets, Holes punched	9.98	0.241	0.69	1.54	1.92	47,925	44,000	63.9	65.9	Plate tore
42	Iron plate, Steel rivets, Holes punched	10.00	0.258	0.69	1.65	1.92	47,925	44,000	63.9	63.1	Plate tore
37	Iron plate, Iron rivets, Holes drilled	10.00	0.244	0.69	1.69	1.87	47,925	38,000	60.7	55.8	Shear of 3 rivets, which also fractured under heads, 2 plate ligaments tore
38	Iron plate, Iron rivets, Holes drilled	10.00	0.258	0.69	1.73	1.87	47,925	38,000	57.4	58.4	Part shear, Part tearing
51	Steel plate, Iron rivets, Holes punched	9.97	0.374	0.76	2.30	2.27	53,330	38,000	43.4	45.4	Rivets sheared
52	Steel plate, Iron rivets, Holes punched	9.96	0.374	0.76	2.30	2.27	53,330	38,000	43.4	43.6	Rivets sheared
53	Steel plate, Steel rivets, Holes punched	10.00	0.375	0.76	2.30	2.27	53,330	44,000	50.0	64.1	Rivets sheared
54	Steel plate, Steel rivets, Holes punched	10.00	0.372	0.76	2.30	2.27	53,330	44,000	50.4	63.5	Rivets sheared
242	Steel plate, Iron rivets, Holes punched	10.03	0.496	0.82	2.84	2.64	57,215	38,000	36.7	38.2	Rivets sheared
294	Steel plate, Iron rivets, Holes punched	10.03	0.492	1.00	2.40	3.93	57,215	38,000	48.6	51.2	Plate tore
295	Steel plate, Iron rivets, Holes punched	10.04	0.495	1.00	2.42	3.93	57,215	38,000	48.7	42.2	Plate tore

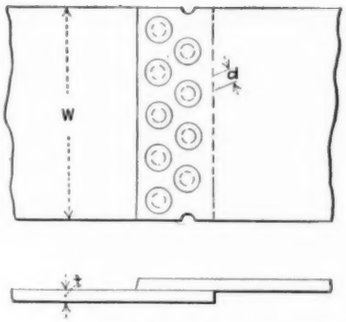
joints or straps than to any other cause, the bending stress due to unsymmetric design of the standard boiler joints being almost negligible compared with the first-named stresses if present, and are well provided against by a factor of safety of 5.

The worst bending stresses somewhere near or in longitudinal joints—that is, those due to imperfect forming—can never be entirely avoided, not excepting butt joints with straps of equal width, so long as certain practical

See Fig. 7 (here Fig. 1) of the Apr. 15, 1913, article referred to.

There are known quite a few cases of cracking of shell plates in or near butt joints which have been attributed to unsymmetrical design. Two of these were the subject of articles in *Power*, Jan. 26, and Nov. 30, 1909, but the only case of a butt joint known to the writer, where a serious explosion resulted, due to cracking and subsequent complete failure of the joint, was one where the joint was

the typical marine butt joint with straps of equal width, shown in Fig. 2. This explosion occurred a few years ago in the harbor of Rotterdam, aboard a river boat. A more detailed account of this case can be found in the *Zeitschrift fur Dampfkessel und Machinen betrieb* of Nov. 22, 1912. In butt seams there is an additional element to be reckoned with, likely to produce severe local stress in or near the joints; namely, the fact that the straps may be imperfectly formed, too deep or too shallow to fit the contour of the shell properly. And the temptation is great indeed to form the outer strap slightly deeper than necessary in order to be sure that the calking edges touch the shell after the joint is riveted. When such straps are then riveted in position, the shell will have to give and partly assumes the shape of the strap, causing the joint as a whole to be out of round with the rest of the shell. The local distortion that may result is well illustrated in the article of Nov. 30, 1909, already referred to.



Straps of equal width are of course no more immune from this than any other design. This fact was well proved by the disastrous explosion of the boiler previously referred to in connection with the equal-strapped butt joint shown in Fig. 2.

An investigation brought out the fact that the makers of this boiler at the time of its manufacture did not possess the proper equipment for forming the shell ends and butt straps to a reasonable conformity with the contour of the shell. The result was a severe breathing action causing the crack along the butt strap (shaded in the sectional view of the plates, Fig. 2) and finally leading up to complete disrup-

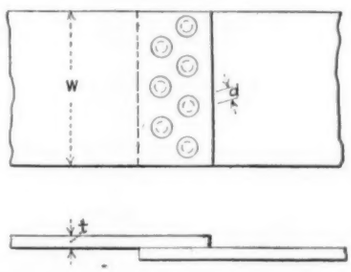


TABLE 2. DOUBLE-RIVETED LAP JOINTS

Test No.	Materials Rivet Holes Drilled or Punched	Dimensions W., In.	T., In.	D., In.	Net Section, Sq. In.	Shear Area, Sq. In.	Actual Tensile Strength of Plate, Lb. per Sq.In.	Assumed for Calculation Shearing Strength of Rivets, Lb. per Sq.In.	Calculated Efficiency, A.S.M.E. Code, per Cent.	Tested Efficiency, per Cent.	Remarks
85	Iron plate, Iron rivets, Holes drilled	10.00	0.264	0.50	1.98	1.77	47,925	38,000	53.1	60.3	Rivets sheared
86	Iron plate, Iron rivets, Holes drilled	10.00	0.236	0.50	1.77	1.77	47,925	38,000	59.3	65.3	Plate tore
87	Steel plate, Steel rivets, Holes drilled	9.98	0.241	0.50	1.80	1.77	55,765	44,000	58.8	76.3	Part shear, Part tearing
88	Steel plate, Steel rivets, Holes drilled	9.97	0.245	0.50	1.83	1.77	55,765	44,000	57.9	79.5	Plate tore
434	Steel plate, Iron rivets, Holes punched	10.00	0.252	0.70	1.61	3.46	55,765	38,000	63.9	74.9	Plate tore
435	Steel plate, Iron rivets, Holes punched	10.00	0.254	0.70	1.63	3.46	55,765	38,000	64.2	74.3	Plate tore
60	Steel plate, Iron rivets, Holes punched	10.00	0.363	0.76	2.24	4.08	53,330	38,000	61:7	73.2	Plate tore
61	Steel plate, Iron rivets, Holes punched	10.00	0.370	0.76	2.29	4.08	53,330	38,000	61.9	63.8	Plate tore
70	Iron plate, Iron rivets, Holes punched	9.98	0.397	0.76	2.39	4.08	47,180	38,000	60.3	60.5	Plate tore
71	Iron plate, Iron rivets, Holes punched	9.98	0.389	0.76	2.39	4.08	47,180	38,000	61.5	60.4	Plate tore

TABLE 3. DOUBLE-RIVETED LAP JOINTS

Series	Test No.	Dimensions W., In.	T., In.	D., In.	Net Section, Sq. In.	Shear Area, Sq. In.	Actual Tensile Strength of Plate, Lb. per Sq.In.	Assumed for Calculation Shearing Strength Rivet, Steel, Lb. per Sq.In.	Calculated Efficiency, A.S.M.E. Code, per Cent.	Tested Efficiency, per Cent.	Remarks
XI Hand Riveted	1480	10.10	0.379	0.8	2.604	3.57	59,940	44,000	68.0	76.3	Plate tore
	1481	10.11	0.361	0.8	2.485	3.57	59,940	44,000	68.2	71.9	
	1482	10.10	0.379	0.8	2.604	3.57	59,940	44,000	68.0	70.6	Rivets sheared
XII Hydraulic Riveted	1480–1	10.10	0.379	0.8	2.604	3.57	59,940	44,000	68.0	78.1	Plate tore
	1482–1	10.10	0.379	0.8	2.604	3.57	59,940	44,000	68.0	80.3	
XIII Hydraulic Riveted	1480–2	10.10	0.379	0.8	2.604	3.57	59,940	44,000	68.0	66.5	Rivets sheared
	1482–2	10.10	0.379	0.8	2.604	3.57	59,940	44,000	68.0	67.8*	
XI Hand Riveted	1486	10.93	0.736	1.1	4.796	6.723	56,920	44,000	59.6	70.0	Plate tore
	1487	10.95	0.726	1.1	4.738	6.723	56,920	44,000	59.6	71.9	
	1488	10.95	0.736	1.1	4.807	6.723	56,920	44,000	59.6	70.6	
XII Hydraulic Riveted	1486–1	10.93	0.736	1.1	4.796	6.723	56,920	44,000	59.6	70.0	Plate tore
	1487–1	10.93	0.746	1.1	4.872	6.723	56,920	44,000	59.7	68.3	
	1488–1	10.95	0.736	1.1	4.807	6.723	56,920	44,000	59.6	63.2	Rivets sheared
XIII Hydraulic Riveted	1486–2	10.93	0.736	1.1	4.796	6.723	56,920	44,000	59.6	60.7	Rivets sheared
	1487–2	10.93	0.746	1.1	4.872	6.723	56,920	44,000	59.7	62.8	
	1488–2	10.95	0.736	1.1	4.807	6.723	56,920	44,000	59.6	60.6*	

*The rivet steel used in series XIII was thought to be a softer steel than was used in the other series. Through an oversight, the exact shearing strength of this steel could not be ascertained after the tests were made

tion at a pressure a little below the maximum allowable. Attention to these practical considerations of giving the boiler joints the proper circular contour would appear

to be of far greater importance than the theoretical ones of greater elaboration in the efficiency calculations of joints and the unsymmetrical pull of joints, such as shown in the examples of the A. S. M. E. Code.

Another factor that is apt to be overlooked is the expansion of a boiler shell, due to pressure and temperature.

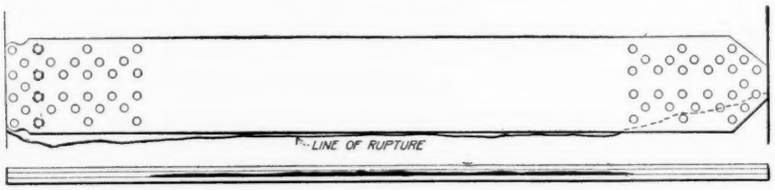


FIG. 2. JOINT CRACKED PROBABLY BECAUSE OF BEING OUT OF ROUND

FIG. 3. VIEW OF BENDING ACTION OF SHELL, EXAGGERATED

While this may not be much, yet it may not be a negligible factor, which may be an addition to possible existing local stress from other causes. From the fact that a riveted boiler joint, and especially a butt joint, necessarily constitutes a considerable local increase in the thickness of the shell body, which of course is less flexible than the rest of the shell, any stretch in the shell circle must necessarily result in local bending stress near the joint. Fig. 3 gives an exaggerated view of what is meant.

As regards the relation between the actual and the nominal efficiency of riveted joints, concerning which Mr. Blackburn makes some interesting deductions, it would not appear from actual pulling tests of joints that much value can be attached to those deductions; at least the 19.2 per cent. strength for a single-riveted lap joint as found by Mr. Blackburn in contrast with the efficiency allowed by the A. S. M. E. Code would seem quite unusual.

The series of pulling tests given in the tables are rather old, but nevertheless of value, and show that, at least with the A. S. M. E. Code approximations of the strength of the few types of joint that were the subjects of the tests, there is not much fault to find. The single-riveted lap joints, Table 1, and the double-riveted lap joints, Table 2, were tested at the Watertown Arsenal in 1882 by the United States Government. The test records of double-riveted lap seams, Table 3, and double-riveted butt seams, Table 4, are gathered from the "Proceedings of the Institution of Mechanical Engineers," London, 1885.

The calculated efficiencies according to the A. S. M. E. Code requirements compare well with the tested efficiencies; in fact, they almost all tested stronger than the figures show them to be, while the few that tested weaker came close to the calculated efficiency.

There appears to be little on record that is reliable concerning tests of the wider joints with three, four and five rows of rivets, and since it seems logical that the distribution of stress in succeeding rows of rivets is more or less unequal, as referred to by Mr. Blackburn, it would be of great value if there were proper test data available for general publication, so that it could be established whether this unequal distribution of stress affects the actual efficiency of the wider joints to such a degree as to warrant consideration in calculations, and of establishing a limit on the number of rows of rivets below the customary number at present in common use.

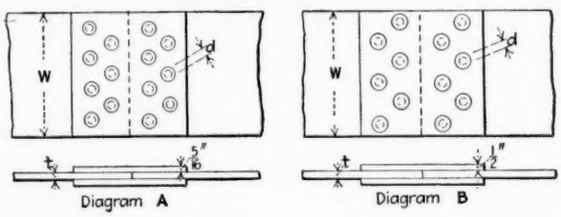


TABLE 4. DOUBLE-RIVETED BUTT JOINTS

Series	Test No.	Dimensions W., In.	T., In.	D., In.	Net Section, Sq. In.	Shear Area, Sq. In.	Actual Tensile Strength of Plate, Lb. per Sq.In.	Assumed for Calculation Shearing Strength of Rivets, Lb. per Sq.In.	Calculated Efficiency A.S.M.E. Code, per Cent.	Tested Efficiency, per Cent.	Remarks
XI Hand riveted (See diagram A)	1483	9.67	0.403	0.7	2.766	5.45	56,480	44,000	70.9	80.3	Plate tore
	1484	9.66	0.383	0.7	2.627	5.45	56,480	44,000	71.0	81.4	
	1485	9.65	0.399	0.7	2.727	5.45	56,480	44,000	70.8	78.9	
XII Hydr. riveted (See diagram A)	1483–1	9.67	0.403	0.7	2.766	5.45	56,480	44,000	70.9	81.1	Plate tore
	1484–1	9.66	0.383	0.7	2.627	5.45	56,480	44,000	71.0	81.0	
	1485–1	9.65	0.391	0.7	2.678	5.45	56,480	44,000	70.9	81.6	
XIII Hydr. riveted (See diagram A)	1483–2	9.67	0.403	0.7	2.766	5.45	56,480	44,000	70.9	77.3	Plate tore
	1484–2	9.66	0.383	0.7	2.627	5.45	56,480	44,000	71.0	77.5	
	1485–2	9.65	0.391	0.7	2.678	5.45	56,480	44,000	70.9	76.8	
XI Hand riveted (See diagram B)	1489	13.20	0.740	1.1	7.312	11.52	55,660	44,000	74.8	70.7	Plate tore
	1490	13.20	0.737	1.1	7.290	11.52	55,660	44,000	74.9	71.8	
	1491	13.24	0.739	1.1	7.332	11.52	55,660	44,000	74.9	71.3	
XII Hydr. riveted* (See diagram B)	1490–1	13.20	0.737	1.1	7.29	11.52	55,660	44,000	74.9	67.4†	Plate tore
	1491–1	13.24	0.739	1.1	7.33	11.52	55,660	44,000	74.9	67.6†	
XIII Hydr. riveted* (See diagram B)	1490–2	13.20	0.737	1.1	7.29	11.52	55,660	44,000	74.9	68.7†	Plate tore
	1491–2	13.24	0.739	1.1	7.33	11.52	55,660	44,000	74.9	66.7†	

*These joints were riveted up with too low a hydraulic pressure. †The tested efficiencies of the test pieces per diagram B being a little low can probably be traced to the fact that the group of rivets constituting each row are not central with the test piece.

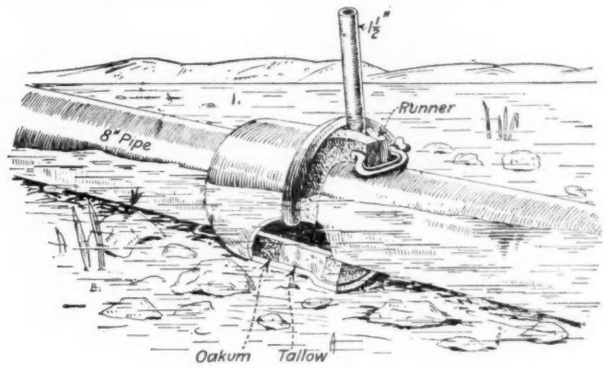
Hartford, Conn. H. J. VANDER EB.

Annealing Steel Has for Its Object (a) completely undoing the effect of hardening, leaving the steel in its softest and most ductile condition; (b) removing any strains set up by rapid cooling, particularly if the rate is different in different parts of the piece; (c) refining the grain. For (a) and (b) it is sufficient to heat below the critical point, say to 1,110 deg. F., but for (c) the temperature must be raised above the critical point.—Bulletin, U. S. Bureau of Mines.

Pouring Lead Joint Under Water

I am not a native son of Missouri, nevertheless I am in the same class as J. Lewis in *Power* of Oct. 17, page 567, in regard to pouring a lead joint as described on page 458 of the Sept. 26 issue, and would like to see the operation performed, especially since I have done some tough jobs myself.

The packing would have to be absolutely water-tight; otherwise, as the tallow was melted by the entering lead,



MAKING LEAD JOINT IN WET PLACE

the water would enter so rapidly that it would instantly chill the lead. If the two gaskets are water-tight, would it not be better to draw out the water entrapped between them and pour in a small quantity of oil to prevent the "blowing" of the lead?

However, there should be no trouble in making a joint under water when the pipe is near enough to the surface to fix it up as described by Mr. Sheehan, nor will there be any difficulty with the use of shredded lead or thin strips of sheet lead. A ten-year-old boy could make a tight joint with the former, and all that is necessary to insure a good joint with lead strips is to see that enough is used, and that it is well calked in. The old-fashioned cold-lead joint will give good results if ordinary care is taken. JAMES E. NOBLE.

Kingston, Ont., Canada.

Lubricator Pump Will Not Feed

When Mr. Ralston, on page 922 in the issue of June 27, blames a vacuum because his force-feed pump does not start to pump, he is on the right track; but the vacuum is not caused by condensation in the delivery pipes, as he suggests, but is due to the piston suction of the pump.

In order to get steam into the delivery pipes, not only would the check valves have to leak, but the three ball checks on the delivery plunger of the pump would have to leak also. Moreover, the oil in the delivery pipe would have to be driven back past these four check valves in series before steam could get into the delivery pipe to condense and form a vacuum. Then, too, the throttle is shut and there is no steam pressure to back up through these valves even if all of them did leak.

When the throttle is closed, the engine is turning over by its own momentum. The piston, moving out, while the exhaust valve is closed and the admission valve open, pumps the oil out of the oil pump and the discharge pipes, leaving them empty. When the throttle is opened again, the pump would have to handle air against boiler pressure until it got hold of the oil, but there would be no oil for it until the sight-feed plunger had pumped some. When the unions on the discharge pipes are opened, the delivery plunger expels the air, picks up the oil, and the pump starts to work all right. The pump is not at fault, neither is the method of filling it; but the trouble will remain so long as the oil is delivered below the throttle valve.

I prefer to deliver the oil to as high a point as possible, as I believe that by so doing the admission valve gets a more even supply of oil. Perhaps that is the trouble also with the two other makes in the same plant, for I presume they too deliver to the valve chambers.

If the delivery point is left as it is, a valve should be inserted in the delivery lines to be shut before the throttle is closed; but care should be taken to disengage the pump ratchet before the valve is closed, so as not to damage the pump. On starting, the order of events would be to open the throttle valve, then the small valve in the oil delivery and last of all the ratchet of the pump. Perhaps it would be better to take off the ells in the delivery pipes and put on tees, to which small check valves may be attached to act similarly to a vacuum breaker. R. MANLY ORR.

Vancouver, B. C.

Isolated Plant or Central Station

The question of manufacturing electric current or purchasing it is daily becoming more important. There is no doubt as to the comparative cost to small consumers, up to, say, $1,000 or $5,000 per year. The expense of installation and operation of a small plant is naturally greater in proportion to the output than that of a large one.

In a private electric plant for producing light and power for an office building, hotel, factory, etc., there is the opportunity to utilize the exhaust steam for heating the building and for various other purposes for which low-pressure steam is suitable and with comparatively little extra cost for apparatus and connections. If high-pressure steam is required, it can be obtained from the same boilers that furnish the steam for the electric generators, obviating the necessity of an extra boiler for high pressure in addition to the heating boiler. In most central stations where the exhaust steam is not used for heating, expensive condensing apparatus is installed to obtain additional energy from the steam and return the condensate as feed water to the boilers. Where exhaust can be otherwise used, the expense of this elaborate condensing apparatus is saved.

Close attention is required in the use of fuel, oil, water, etc., to avoid waste in the operation of the small plant and care must be taken to avoid accidents and repairs as well as in the large central station and this is the most important point to be kept in mind and carried out in practice, as the saving comes by making every pound of coal and every gallon of oil and water efficient as far as possible.

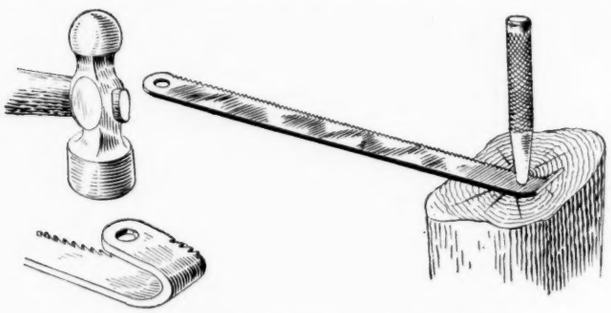
Given a private plant that is as well designed and as carefully operated as the commercial plant, the kilowatt-hour cost should be practically the same at the switchboard. But beyond the switchboard the advantage is with the isolated plant, for it has no outside transmission system to maintain, no high salaries to pay or profits to provide for, no customers' accounts to keep or bills to render and collect.

Unfortunately, in many cases there is a tendency, in the private plant, to be less strict in these things; it is only one of several departments of the business, or the production of light and power is only one of several processes in a manufacturing plant, hotel or office building, and is often given less consideration than it deserves; therefore when it can be bought ready-made at the door, thereby relieving the owner of that detail of management, it is done although it does cost a little more than "home-made" current. A. T. ROGERS.

Port Richmond, N. Y.

Fitting Hacksaw to Frame

Reading H. E. Hoffstadt's article, "Fitting a Saw Frame to Blade," on page 431 in the issue of Sept. 19, impels me to suggest a different way to make use of a



SHORTENING A HACKSAW BLADE

12-in. hacksaw when only a 10-in. frame is at hand, which entails no difficulty.

Anneal one end of the blade in a gaslight or on a piece of burning coal, bend and break it as shown, then punch a hole 10 in. from the other end and the job is done. L. V. LAUTHER.

New York City.

A Dissatisfied Diesel User Challenged

In the Oct. 10 issue of *Power*, I am astonished and pained to read the letter, "A Dissatisfied Diesel User," evidently referring to myself.

In boldly signing from Casper, Wyo., and thus openly identifying our engines, the writer of this letter has placed himself in a most discreditable light. Under the circumstances, as his employer, I must request space in your columns for an equally public disclaimer.

In justice to the manufacturers of our engines it should be stated that while Mr. Wass, without previous Diesel experience, was nominally superintendent of our plant for some six months, his personal contact with the engines was limited on account of ill health; that his figures are erroneous and statements misleading since, for instance, no rings were changed or pistons removed while he was in Casper; and that the "state of decrepitude" mentioned is a personal foreboding, since the circumstances hypothecated have never arisen. As to his views upon vertical vs. horizontal engines, it is recalled that he came to us recommended by a concern which manufactures the horizontal type.

Casper, Wyo. P. N. NUNN.

The Young Engineer's Outlook

Your editorial on "The Young Engineer's Outlook in the issue of Oct. 10 is both interesting and timely. That the field for the young, clean-minded steam engineer of today is broad, the gray-haired members of the craft will not dispute. The man that decries his own chosen calling is a pessimist anyway and beneath notice, and the old Scotch proverb quoted (It's an ill bird that fouls his own nest) fits him exactly.

For the benefit of the young readers of *Power* who have a leaning toward steam engineering, possibly with the intention of making it their life work, I would call attention briefly to marine engineering and its possibilities from a practical point of view. Although not a marine engineer, I have made many sea voyages, and the chief engineer (he with the neat-fitting blue uniform, gold lace, etc.) is the first person I get acquainted with after I have seen the purser and been assigned a seat at table. My information is therefore first-hand, and let me state that I have yet to find one chief engineer, first assistant, second assistant, third assistant or oiler in the American merchant marine who expressed himself as dissatisfied with his calling.

To become a chief engineer on deep water calls for good health, a studious mind and, greatest of all, a determination to succeed, for the life of the marine engineer is not a bed of roses. He begins as an oiler at, say, $40 a month and "found," although some steamship lines take young men as cadets at $5 a month and "found." This latter salary, however, applies only to young boys who know nothing about engineering and is paid to them for the privilege of giving them orders. As a matter of fact, the cadet gets all he is worth, for a green hand is decidedly in the way in a ship's engine room.

The oiler is usually a young man of 20 or thereabout, crazy over marine engines, who has persuaded some chief engineer to sign him on as an oiler. He studies steam engineering, and after he has been at sea for three years (machinists by trade exempted; they can apply anytime) he is considered qualified to apply for a third assistant engineer's papers. If he has been studious and passes his examination and gets that certificate empowering him to undertake the duties of a third assistant engineer, he is a proud young man and this fires him to greater effort. He continues his studies, keeps his body healthy and his mind clean, works hard, and in time he is promoted to second assistant, then first assistant, and last, chief engineer, to draw a nice salary and to be paid more for what he knows than what he does. He is now a man of authority—a ship's officer—even empowered by the laws of the United States to shoot, if necessary, any man who, while at sea, becomes mutinous and refuses to obey vital orders. Discipline in the American merchant marine is so exact that crews seldom have a chance to plot mutiny. I mention the foregoing fact only to show the amount of authority a chief engineer has at sea.

At the present time there are opportunities for good men in the merchant service, and I want to say to the young engineers, consider the engine room of an American bottom, sailing under "Old Glory," as good a place to work up in as any other. Think it over, young engineers before you decide otherwise. F. B. JACOBS.

Indianapolis, Ind.

Inquiries of General Interest

Slope of Hand-Fired Grate—With a hand-fired furnace what is the advantage, if any, in having the rear end of the grate lower than the front end? J. G. F.

When the air supply is admitted at the front end, there is some advantage in having the rear end of the grate lower than the front end for obtaining greater force of the draft from impingement of the air against the under side of the grate bars. The principal advantage is that with the grate lower at the rear end the fire can be worked easier.

Drag Crank—What is a drag crank, and where is it used? F. P. K.

A drag crank is a double crank in which the crankpin is secured to only one of the crank arms and is allowed a slight radial play in the other crank arm. This type of double crank adapts itself to a difference in the alignment of the shaft on opposite sides of the crankpin. It is used to compensate for settlement of foundations, or uneven wear at the bearings, or wherever it is difficult to maintain the same alignment of connected shafts, as in case of mounting direct-connected generators on both sides of a vertical engine.

Probable Saving by Use of Fuel Oil in Place of Coal—What would be the probable saving by the use of fuel oil at 3 cents per gallon of 8 lb., containing 18,700 B.t.u. per lb., with 75 per cent. boiler efficiency, in place of coal at $6.75 per ton of 2,000 lb., containing 14,500 B.t.u. per lb., with 60 per cent. boiler efficiency? J. W. W.

For realizing the same amount of heat, the cost using the fuel oil would be

$$\frac{\$0.03 \times 14{,}500 \times 2{,}000 \times 0.60}{18{,}700 \times 8 \times 0.75 \times \$6.75} = 0.689$$

or practically 69 per cent. as much as using coal, saving about 31 per cent. in the cost of fuel.

Position of Connecting-Rod Wedge-Block—When the connecting-rod of a horizontal engine is provided with a wedge-block for adjusting the brasses, should the rod be used so the large end of the wedge will be up, or down? G. L. K.

It is preferable to have the rod turned to such a position that the large end of the wedge will be down, so that backing off or failure of the wedge-block fastenings will permit the wedge-block to fall and slacken the pressure on the brasses. With the large end up, falling of the wedge-block might result in setting up the brasses too tight without notice and cause the wedge-block to become jammed so hard as to make resetting very difficult.

Determining Capacity of Safety Valve—What would be the surest way to determine whether a safety valve and its connections are large enough for a boiler? L. B.

Set the valve to blow off at about three-fourths the pressure allowed for the boiler. If the safety valve and its connections are large enough to relieve the boiler of all the steam that can be generated at the lower pressure, they will be of sufficient capacity for the allowed pressure. With all other discharges of steam shut off, and by gradually increasing the intensity of the fire, determine whether the safety valve with forced firing of the boiler will relieve it of all the steam that can be generated at the less pressure. Such a test should not be attempted, however, without ample means at hand for quickly checking the fire and also for relieving the boiler of excessive pressure by discharging the steam from a stop valve direct to the atmosphere.

Steam Delivered to Tenant—What amount of steam would be delivered per hour to a tenant through a ¾-in. pipe if the pressure at the entrance end of the pipe was 30 lb. gage? H. H. H.

The rate of flow deliverable would depend on the length of the pipe and the pressure maintained in the discharge end of the pipe as well as on the size of the pipe and the pressure maintained in the entrance end. When all conditions are stated, and without allowing for condensation from loss of heat, the weight of steam flowing per minute is given by the formula

$$W = 87.54\sqrt{\frac{w(p_1 - p_2)d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

where

W = Flow in pounds per minute;
w = Density or weight per cubic foot of steam at the mean pressure in the pipe;
p_1 = Pressure in the entrance end of the pipe;
p_2 = Pressure in the discharge end of the pipe;
d = Diameter of pipe in inches;
L = Length of pipe in feet.

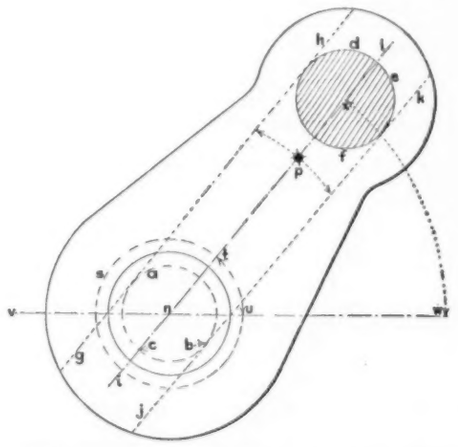
With $p_1 = 30$ lb. gage, and to complete the conditions it is assumed that $p_2 = 25$ lb. gage, then as the mean pressure would be $(30 + 25) \div 2 = 27.5$ lb. gage or $27.5 + 15 = 42.5$ lb. absolute, w, as found from the steam tables for 42.5 lb. absolute would be 0.1009 lb. per cu.ft., and if it is further assumed that the length of pipe is 100 ft., by substitution the formula would become

$$W = 87.54\sqrt{\frac{0.1009(30 - 25) \times (0.75)^5}{100\left(1 + \frac{3.6}{0.75}\right)}} = 1.257 \text{ lb. per min.}$$

or about 75 lb. per hour.

Setting Eccentric without Placing Engine on Center—How can the correct position of an engine eccentric be determined if it has slipped on the shaft and the shaft cannot be turned to place the crank on the dead-center? L. B.

Assume that the crank stands on the center which it has last passed over. Then turn the eccentric on the shaft in the direction of rotation of the engine until the valve opening is correct for the beginning of that stroke of the piston that has been partly accomplished, and make a mark on the eccentric and a corresponding mark on the shaft. The eccentric will be in its proper position after it has been turned farther forward on the shaft through the same angle that the crank stands ahead of the center. The distance measured around the shaft can be determined as indicated in the figure. Assume WX to represent the angle through which the crank has passed beyond the dead-center. Describe the circle abc on the crank end of the shaft with center at the center of the shaft and diameter equal to the diameter of the crankpin def, and with a straight-edge draw the tangents gh and jk.



DETERMINING ANGLE FOR SETTING ECCENTRIC

On the face of the crank locate a point p, midway between the lines gh and jk, and through p and the center of the shaft draw the straight line pi and the horizontal line VW. Then on the face of the crank describe a circle stU of the same diameter as that portion of the shaft that carries the eccentric. This circle intersects the line pi at t and the line VW at U. As the angle tnU is the angle through which the crank has passed beyond the dead-center and the circle stU is of the same radius as the shaft where it carries the eccentric, the distance tU laid off around the shaft at the eccentric will give the amount the eccentric is to be advanced to correspond with the advance of the crank beyond the dead-center.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Single-Phase Power Production*

By E. F. W. Alexanderson and G. H. Hill

SYNOPSIS—Means are suggested for producing single-phase power from a polyphase system without interfering with the normal usefulness of the power plant. The method of operation and the theory of the different types of phase converters and their applications are discussed.

In view of the universal use by power companies of polyphase generation and transmission of electric power for general purposes, the production and delivery of single-phase power must be considered as a special problem. It is settled that polyphase generation and transmission is most efficient, flexible and economical, and the problem presented to power companies when the demand for single power appears is how this may be produced or derived from their polyphase system.

Single-phase power may be obtained by: (1) Separate generating and distribution systems designed for single-phase loads; (2) polyphase generation and distribution of single-phase loads between the phases so that in effect the load becomes a polyphase load; (3) generation and transmission as polyphase with motor-generator sets at substation; (4) mixed single-phase and polyphase loads furnished by the same distribution system in combination with method of correcting the unbalancing effect of the single-phase load.

COMPARISON OF PHASE-CONVERTING DEVICES

The first method comes under the head of special and abnormal development. It has the disadvantages of increased size, weight and cost of generating equipment and a lower efficiency of generation and transmission as compared with the polyphase system. Single-phase generators have been built only for 25 cycles or lower, and to a limited extent for special purposes. As compared with other ways of obtaining single-phase power, this method seems to offer the least promise of general usefulness.

The second method has the advantage of the polyphase alternator. It is generally used for incandescent lighting, distribution, and for power and heating where the unit of energy capacity is small and adapted to division between the phases, so as to result in very little, if any, unbalancing. It has been proposed and used to a limited extent for heavy single-phase loads, but the difficulty of preserving even an approximate balance between phases makes this method insufficient for large power requirements. It has the further disadvantage of requiring generators of the same frequency as the load demands.

Method No. 3 has the advantage of entire freedom as to generator and transmission and permits a single-phase load of any frequency or power factor to be drawn from any standard polyphase system without disturbing the balance or regulation. It provides means, moreover, of improving the power factor of the system by synchronous motors, and from the power-system standpoint it is the most desirable of all methods when large unit amounts of single-phase power is demanded. It is the only method of producing low-frequency single-phase power from a 60-cycle system. The only objection that is made to this method is the cost of motor-generator sets and of attendance.

The first cost of equipment, it is true, is greater than static transformers alone, but this is balanced to some degree by the lower cost at the power station and in the transmission line, and is fully justified in a large power station since it makes it possible to combine the single-phase load with the general load and obtain the benefit of a higher power factor. The expense of attendance can be entirely eliminated by introducing automatic devices to start and switch the motor and generator, such as are coming into successful use for direct-current synchronous converters, waterwheel generators and other rotating apparatus. This disadvantage, moreover, largely disappears when, as usually happens, a system of single-phase generation is connected to other systems through motor-generator sets for interchange of power.

No. 4 is in general respects the same as No. 2, with the addition of a relatively new development known as the phase-converter, which preserves the balance of the system, even when large blocks of single-phase power are taken from the system. Its use greatly extends the possibility of connecting single-phase loads directly to a polyphase system, provided the frequency does not have to be changed.

The earliest known form of phase conversion is splitting the phase by inductance and capacity. In this case the energy of one phase is stored for a fraction of a cycle and released again so as to make the same energy active in another phase. All methods of phase conversion, therefore, involve the storage of energy. Even the phase conversion so-called of wattless current necessarily involves storage of energy. The expression "wattless energy" is not such a contradiction as it has sometimes been claimed to be. When energy is wattless it means that the energy delivered during one portion of a half-cycle is returned during the other portion of the same half-cycle. Therefore the average energy flow is zero. But at the same time we must not forget that even if a current is completely wattless, there is a real energy flow in both directions. Thus if we wish to change the phase of the current, whether energy current or wattless current, we must provide means for storing the momentary energy flow for a time corresponding to the change of phase that is to be effected.

The method of storing energy in inductances and condensers is very convenient for high-frequency current, but has not, up to the present time, found much practical application for a low-frequency power current. There is therefore, for phase conversion on a large scale, only one type of apparatus that can be considered, and that is a rotating machine which stores the energy in the mechanical inertia of the rotor.

In order to arrive at an understanding of the physical function of the phase converter with a rotating machine, several different points of view are possible.

The phase converter is built as a two-phase induction motor or synchronous motor with a squirrel-cage rotor; one phase is a motor phase and the other is a generator phase. The output of the motor phase is equal to the output from the generator phase, not only in the average value of the power flow, but in the instantaneous value of energy flow which is delivered and returned during the same half-cycle. The only difference between the energy flow in the two-phase winding of the converter is that the momentary value of current, volts and energy, is delayed one-fourth of a cycle in one winding in relation to the other. The squirrel-cage is the medium for the transfer of energy, and the mechanical mass of the rotor provides energy storage. In order to make it possible to store the energy in the rotor, there must be a corresponding change of speed, and therefore the rotor must go through a cycle of speed changes during each half-cycle of the alternating-current flow. This speed change of the rotor is evident by the vibration which is a characteristic of any single-phase machine. The speed change of the rotor, however, has nothing to do with the electrical function of the machine in performing as a phase converter. If we could couple the rotor to a flywheel of infinite weight so that the speed change would be zero, the converter would perform in the same way.

SHUNT CONVERTER WITH PHASE BALANCER

Various means can be provided for producing the desired energy flow and will lead to two different types of phase converters. Broadly, it can be stated that whatever means are provided, the result of these means must be the desired flow of current through the winding, and therefore the means must consist in providing the necessary electromotive forces to cause these currents to flow through the winding.

One method of providing these electromotive forces is to use an auxiliary generator which impresses the desired electromotive force on the winding. Instead of a generator any other convenient source of electromotive force, such as a transformer or an induction regulator.

Another means is to connect the winding of the converter with reference to the source of power and the load in such a way that the electromotive forces are furnished automatically by the source of power.

The first method leads to the phase converter connected in shunt to the line and is the type that has been adopted in the phase-balancer set of the Philadelphia Electric Co.; for the sake of brevity this type may be referred to as a shunt converter. The function of the shunt converter is to transfer energy from one phase to another in a polyphase system, so as to neutralize the effect of single-phase loads drawn from the same system in another place and thereby maintain the polyphase system balanced.

*Abstract from a paper presented at the 325th meeting of the American Institute of Electrical Engineers at Philadelphia, Oct. 13, 1916.

The sets consist of a main converter and an auxiliary balancing machine which is controlled by automatic regulators. The main converter is mechanically connected to a generator which is called a balancer. The function of this balancer is to circulate polyphase currents of the desired phase and magnitude in the windings of the converter. This auxiliary generator is small compared to the converter because its output is used only to overcome the losses and inductive drop in the windings of the main shunt-phase converter.

The second method of producing the desired flow of current in the system leads to the series converter. In this type of converter the single-phase circuit is in series with one phase of the converter. The series converter as applied for changing from single-phase power to polyphase power, is described in a paper read by one of the authors in 1911, before the A. I. E. E. The same arrangement is well adapted for change of polyphase to single-phase power, and this method is in some cases preferred to the shunt converter. The function of a series converter is not to correct for a single-phase load that has been placed on a polyphase line, but to change the single-phase load into a polyphase load before it is connected to the line.

THE SERIES CONVERTER EXPLAINED

The function of the series converter is easily explained in connection with a quarter-phase system, but it is obvious that it can be used in a three-phase system by the use of a Scott transformer connection. The object in the use of the converter is to distribute the single-phase load equally in the two phases of the quarter-phase system. If the problem were to distribute the single-phase load in two circuits of a single-phase system, it is easy to see how this could be done by the use of a series transformer. The single-phase load might be put directly in series with one circuit through the intermediate of a series transformer. If this transformer has a ratio of 1:1, the current would be equally distributed on the two circuits at all loads. The two phases of the quarter-phase system differ from the two circuits of the single-phase system for our present purpose only by the relative time phase. However, if the phase converter may be used as a transformer which changes the time phase of the time current between its primary and its secondary to the desired degree, it can be used as a series transformer between the single-phase load circuit and one of the phases of the quarter-phase system in the same way and with the same characteristics as previously stated with reference to the ordinary series transformer used to distribute the load on two circuits of the single-phase system.

The change of a single-phase load into a polyphase load is automatic and results in the perfect distribution of current in the two phases at all loads. The voltage delivered to the single-phase circuit has a slight drop with increasing load and has the same characteristics with reference to current and power factor that would be obtained by placing an impedance in series with the single-phase circuit equal to the impedance of the windings of the converter.

In regard to efficiency and size, the phase converter can be considered as being in the same class as the synchronous condenser. In fact it has essentially the same structure, the difference being that the squirrel-cage winding, which is usually employed in the synchronous condenser to counteract hunting, becomes in the phase converter the main-rotor winding, while the field winding on the synchronous condenser is reduced to a small winding sufficient to carry no-load excitation. Because of the similarity in structure, the same machine can act as a synchronous condenser and phase converter at the same time if the windings are proportioned for this purpose. The fact that the machines can be designed so that they are useful as synchronous condensers and phase converters simultaneously is worth consideration in the application of the methods of phase conversion, as several methods of application are possible.

In the first place it is possible to place the phase converters either in the power house or at any desired place on the distribution system. Synchronous condensers may be needed on distribution systems for the sake of counteracting low power factor, and such condensers can, if desired, be designed so that they can in addition be used as phase balancers, in order to make it possible to draw single-phase power from the same system. If, on the other hand, the main load is synchronous converters with unity or leading power factor, it may be more practical to locate the phase balancers in the power station. The single-phase load is usually of low power factor, and the lighting current of the single-phase system may be furnished either to the single-phase distribution system by single-phase synchronous condensers or be furnished in the power house by polyphase machinery after the whole kilovolt-amperes of the single-phase load has been converted to polyphase.

In the latter case the phase converter can be used for power-factor correction as well as phase conversion, but in that event it must be large enough to convert the whole single-phase kilovolt-amperes at a low power factor and then furnish polyphase current to correct for this power factor; whereas in the other case, where the single-phase power factor is corrected for by synchronous condensers, the phase converter needs to convert only the power component of the single-phase load. The choice between these methods of conversion will depend upon local conditions and expediency.

The shunt converter is of particular value when it is expected that single-phase loads may be drawn from different phases of a polyphase system. In such cases unbalancing of the single-phase loads will be partly neutralized and it will be necessary to convert only the difference between the single-phase loads. There are, on the other hand, cases where the series converter can be used to best advantage. Those are cases when it is desired to convert the single-phase load at the point where it is connected to the single-phase system. The series converter has in that case the advantage of simplicity, as the arrangement is automatic and no auxiliary generator or voltage regulator is needed.

Where a single-phase electric-welding machine or arc furnace is to be fed from a polyphase system, the series converter should be recommended. If such an installation has been made with a series converter in order to insure the lowest first cost and it should be desired to add other furnaces to the other phases, the same converter might be used as a shunt converter without any increase of converter capacity, but with the addition of suitable regulating devices.

It has been pointed out that a synchronous condenser has a structure suitable for phase conversion. The same is the case with an induction motor or a single-phase turbo-generator—in fact, any polyphase machine with a squirrel-cage winding. Such machines are always connected in shunt to the line and would therefore be available as shunt converters wherever desired. If, for instance, a power house is built primarily for furnishing single-phase power from single-phase generators, but it is desired to furnish a certain amount of polyphase power in addition, the objection arises that the polyphase voltage is unbalanced in proportion to the single-phase load. In such a case it might be expedient to use the squirrel cage of the turbo generator as a converter medium by adding suitable regulating devices.

The interchange of current between the phases is then already determined by the load conditions, but the electromotive forces necessary to cause this interchange of current appear in the unbalancing of the line. This unbalancing of the voltages can be treated with the same method of analysis as given in the preceding for the unbalancing of current. The unbalancing electromotive forces are resolved into their components and the correcting electromotive force may be furnished by a generator driven either by the turbine shaft or by a synchronous motor. This generator has the same characteristics and functions as the auxiliary balancing generator in the phase-converter sets. A power house for mixed single-phase and polyphase loads equipped in this way can be operated in multiple with other power houses using standard polyphase generators.

MIXED SINGLE-PHASE AND POLYPHASE LOADS

The methods that may be employed in order to equip a power house so that it can take on mixed single-phase and polyphase loads, can be classified in the following groups:

A. The use of standard polyphase generators and phase converters for correcting the unbalanced load. The phase converter may be used either in the power station or substation and may be one shunt converter or two series converters.

B. The use of special generators with squirrel-cage winding adapted for mixed single-phase and polyphase loads with an equipment of automatic apparatus to prevent the unbalancing of the voltage that the single-phase load tends to produce.

C. The use of standard polyphase generators and special single-phase generators connected to the same busbars with automatic means for regulating the governors and fields of the single-phase generators so that they will absorb the entire unbalancing of the current.

The choice between these three methods of balancing a power system with mixed loads will depend upon local conditions and general expediency. All three methods have the advantage of affording duplication of the transformation and distribution system. The first method involves the use of the phase converter, introduces the least change in the standard polyphase power system and is adapted for the cases where the polyphase load is predominant.

The second method is adapted for cases where the single-phase load is predominant and has the merit of making all the

generating units available for both single and polyphase power, as the system may demand. It is thus adaptable to growth and changes in the system, to preservation of good load factor and interconnection with other power systems.

The third method does not offer any particular advantages over the other two, but is mentioned for the sake of completion. Its use might be considered in cases where single-phase and polyphase generators are already in use in the same power house and it is desired to use the polyphase distribution system for taking on single-phase loads. The efficiency of all three methods may be said as a whole to be on a par. In specific cases there is some slight advantage for each of the systems, but the determining factors will not be so much inherent efficiency of the electrical apparatus as the difference in load factors and the influence of load factors on steam economy.

Recent Court Decisions

Conveyance of Water-Power Rights—One who purchases a tract of land is bound to know of the existence of any recorded right of way across the premises for the purpose of maintaining a raceway in connection with a water-power plant, although the raceway has not yet been constructed. As a general rule the owner of such a right of way is not entitled to enlarge the raceway after it has been constructed, unless the right is clearly reserved. (Oregon Supreme Court, Patterson vs. Chambers' Power Co., 159 "Pacific Reporter," 568.)

Water-Power Rights—The owner of a dam on a stream, having acquired water-power rights before a city appropriated water from the same stream for water-works supply, is entitled to recover damages sustained by him through consequent diminution in his power, but can recover nothing against the city on account of the value of the water taken from his millpond. Being concerned only in the use of the water, he has no interest in its value for purposes of consumption. (Kansas Supreme Court, Wallace vs. City of Winfield, 159 "Pacific Reporter," 11.)

Duty to Inexperienced Employees—An electric-power company is liable for injury sustained by an inexperienced electrician's helper through electric shock resulting from approach near primary wires carrying 60,000 volts of electricity, which wires were negligently constructed within six feet from the ground and near the place where the injured man was required to work; it appearing that he knew of the danger of touching a live wire, but not that high-tension current would jump to a person approaching near it. (United States Circuit Court of Appeals, Ninth Circuit; Sheaff vs. Pacific Power Co., 234 "Federal Reporter," 553).

Liability for Death by Lightning—Although an employer maintaining an electric-power house is not liable for death of an employee, due solely to a bolt of lightning, the accident being attributed in such case to an act of God, there is liability when it appears that the death would not have resulted except for the fact that the employer had negligently failed to ground the wire over which the lightning came. The burden is upon the employer to prove that an act of God was the sole cause of an accident, when that is relied upon as a defense against liability. (South Carolina Supreme Court, Sloan vs. J. G. White Engineering Co., 89 "Southeastern Reporter," 564.)

NEW PUBLICATIONS

PRINCIPLES OF ALTERNATING-CURRENT MACHINERY. By Ralph R. Lawrence. Published by McGraw-Hill Book Co., Inc., New York, 1916. Cloth; 5½x8 in.; 614 pages; 273 illustrations. Price, $4.50.

This book is the result of a number of years' experience in teaching the subject of alternating-current machinery to senior students in electrical engineering and has been developed from a set of printed and neostyled notes used for several years by the author at the Massachusetts Institute of Technology. The work is divided into eight sections under the headings: Synchronous Generators, Static Transformers, Synchronous Motors, Parallel Operation of Alternators, Synchronous Converters, Polyphase Induction Motors, Single-Phase Induction Motors and Series and Repulsion Motors.

The book deals with the principles underlying the construction of alternating-current machinery, but is in no sense a book on design. Mathematical and analytical treatment has been employed freely throughout the work where such treatment offers an advantage. In many cases the author has used calculus in his mathematical reasoning. In general the notation recommended by the American Institute of Electrical Engineers has been used. Many of the illustrations of the various pieces of apparatus are pen-and-ink drawings made from photographs. The book is intended as a text suited to the needs of students in the senior classes who have had the advanced mathematics, but it should be well received also by the advanced workers in the electrical industry.

HOW TO MAKE LOW-PRESSURE TRANSFORMERS. By Prof. F. E. Austin. Third edition. Published by the author at Hanover, N. H., 1916. Cloth; 4½x7 in.; 22 pages; 16 illustrations. Price, 40c.

This is the third edition of this little book and it has been enlarged with new material to meet the demands of those who wish to construct small transformers for experimental purposes. Several methods are given for constructing these devices to operate from 110 or 220 volts on the primary, giving various combinations of low voltages on the secondary. From the variety of constructions given the student should be able to select a type that will be best suited to the material that may be at hand from which to build the transformer. The book is excellent in so far as telling "how to do the work," but the amateur perhaps would be better satisfied had the text also told "why" the particular dimensions were selected; that is, preliminary calculations showing the methods of determining the items might have enhanced the usefulness of the work.

APPLIED ELECTRICITY FOR PRACTICAL MEN. By Arthur J. Rowland, professor of electrical engineering at Drexel Institute. Published by McGraw-Hill Book Co., Inc., New York, 1916. Cloth; 5x7½ in.; 375 pages; 323 illustrations. Price, $2.

Many elementary books have been written on electricity. They appear to have been divided into two classes. One attempts to cover the whole field of electrical science with the result that it must be very superficial, and the other deals with the theoretical principles only and does not attempt to apply the principles to the practical apparatus. This book, however, is written wholly from the standpoint of the one who constructs and operates electrical circuits and machinery, and is the result of the author's 20 years' experience in teaching applied electricity to practical electrical workers who expected to make direct application of the knowledge gained in the lecture room and laboratories to commercial apparatus.

The work is divided into 18 chapters. The first four treat of the fundamental principles of the electric circuit, electromotive force and Ohm's Law, magnets and magnetic flux, and the calculation of combined resistances. Three chapters are devoted to the study of direct-current machinery and take up the general characteristics, construction and operation of the direct-current generator, the drum armature and multipolar machines, and the general treatment of armature winding, and different types of direct-current motor starters and controllers. The principles of alternating current and polyphase circuits are treated in two chapters. The four chapters on alternating-current machinery are devoted to a study of the construction and operation of alternators, synchronous converters, the direct-current three-wire generator, transformers both of the constant-potential and constant-current types, the different types of alternating-current motors including the series, single-phase and polyphase induction, and synchronous motors, considerable space being given to the principles of operation, methods of starting and speed regulation of the various types of alternating-current motors. The chapter on storage batteries gives consideration to the different types of batteries, their care and methods of charging, including the mercury-arc rectifier, vibrating-contact rectifiers and the aluminum valve. Three chapters are devoted to direct-current systems of distribution, electric lighting and wiring.

Many problems are given at the end of each chapter to be worked out by the student. Outside of the class room the student will find this part of the work disappointing, as the answers are not given; consequently it will be difficult for him to ascertain if his solutions are correct. It is to be hoped that the author will see the necessity of this and have the answers to these problems published, as this would seem to be one way of increasing the book's field of usefulness to the practical man who wishes to work out these problems for himself. Nevertheless, outside of this apparent discrepancy the book contains a wealth of information for the electrical worker and should find a very wide field of usefulness both in the trade and industrial schools and with electrical workmen who desire to familiarize themselves with the application of electrical power.

Grunting of an Engine is frequently caused by the vibration of the piston rings when they have a trifle too much play between the bull rings. The trouble can partly, if not wholly, be remedied by putting in a set of stiffer piston-ring springs.

Smoke-Abatement Week in Pittsburgh

Cities have Clean-up Day, Fire Prevention Day; why not a Smoke-Abatement week? "Certainly," said Pittsburgh, and she therewith set Oct. 23-27 aside to discuss what has been done, what can be done and what needs to be done to eliminate smoke.

Monday noon, J. W. Henderson, chief of the Bureau of Smoke Regulation, Pittsburgh, addressed the Hungry Club at the Fort Pitt Hotel, giving names and addresses of chronic offenders of the smoke law and praising several who had stopped the emission of objectionable smoke. The talk was illustrated with lantern slides. O. P. Hood, mechanical engineer of the Bureau of Mines, introduced Mr. Henderson. In all of the many smoke talks throughout the week the mechanical stoker was highly commended as an important factor in smoke abatement.

Monday afternoon a meeting was held in the Chamber of Commerce rooms to discuss the setting of a date after which violators of the smoke law will be prosecuted. Notices that the Smoke Bureau intended setting such a date were sent out months ago, and after the hearing the manufacturers and engineers were advised by Mr. Henderson that after Dec. 15 offenders would be sued.

At all the meetings one was impressed with the frequency of the plea on the part of manufacturers and engineers that the difficulty of getting skilled firemen made the work of smoke abatement very trying.

Monday evening Dr. William Holman gave an address on "Soot, as It Affects the Public Health," at Thaw Hall, University of Pittsburgh.

Tuesday noon, Osborn Monnett[1], formerly chief smoke inspector of Chicago, who really standardized the engineering phases of smoke abatement, gave a talk before the Chamber of Commerce, using lantern slides and a motion-picture machine. In reviewing some of the work in Chicago, Mr. Monnett told that when the Smoke Department of that city was reorganized on an engineering basis, it found that approximately 90 per cent. of the boilers in the city were of the horizontal, return-tubular type and were set in the well-known Hartford setting, which was a simple, straight-front setting and, when followed according to the instructions of the Hartford Steam Boiler Inspection and Insurance Co., which standardized the setting, would have the shell only 24 in. above the grate, making smokeless combustion impossible because the volatile matter from the coal would be so soon condensed on reaching the comparatively cool boiler. Furthermore, for these hand-fired settings combustion rates above 20 to 25 lb. of coal per hour per square foot of grate surface was impossible without the production of smoke of objectionable density.

At this meeting Mr. Monnett gave a number of figures showing what had been spent on boiler-room improvements for the purpose of obtaining smokeless combustion, and in a column opposite these figures were given the savings effected by these expenditures. These savings amounted to from three to eighteen times the original investment per year. Considerable work was needed to show which type of furnace was the best for most successfully burning the Illinois coal used in Chicago, and in determining this the Smoke Department found that the dutch-oven furnace was a failure in every case, chiefly because of the heat radiated from the combustion arch down upon the green fuel, causing too rapid distillation of the volatile matter of the coal. The most successful type of furnace is one where the gases after leaving the grate pass through a butterfly arch having two openings above the bridge-wall, then after passing through these arches—for the butterfly arch forms two arches—the gases impinge upon a wing wall in the combustion chamber and are deflected downward. Mr. Monnett said that the City of Chicago spent approximately $40,000 a year in smoke-abatement work and was saving hundreds of thousands of tons of coal thereby. It must be remembered also that the saving effected in the reduction of laundry bills, cleaning of all kinds, and in different diseases amounts to considerably more than the engineering savings.

A reel of motion pictures, showing smoke abatement in locomotive work, proved to be of considerable interest. These pictures were taken at Chicago and at Cincinnati. Most of the locomotives shown were provided with the Altoona specifications, according to which the locomotive firebox is supplied with a number of steam jets that draw air in over the fire and that have multiple jet blowers in the stacks, all being operated by quick-opening blower valves in the cab, one at the right-hand side and one at the left, so that both engineer and fireman may use them. The locomotives were purposely made to smoke, gushing forth dense, black smoke, and at signal the blower valves were opened, the smoke ceasing almost as abruptly as though it had been cut off with a knife.

Wednesday morning Mr. Monnett addressed the engineering students at the Carnegie Institute of Technology, outlining to them the fundamentals of smoke-abatement work in power plants, showing photographs of the different smoke densities, according to the Ringelmann's scale, and explaining to them the smoke unit as standardized at Chicago. A smoke unit is the equivalent of No. 1 Ringelmann scale emitted for one minute. No. 1 smoke is 20 per cent. dense; No. 2, 40; No. 3, 60; No. 4, 80; No. 5, 100 per cent. Thus if a stack emits No. 3 smoke for 6 min., 18 smoke units are charged against it. If this smoke was emitted during one hour's observation, then $(3 \times 6 \times 20) \div 60 = 6$ per cent. is the average density during observation. This is a more equitable means of discovering offenders of the smoke law.

Mr. Monnett stated that smoke of 3.4 per cent. density was about the lowest that might be expected commercially, while for locomotive practice the minimum density would be about 5 per cent. He advised the students that to build a soft-coal fire the grate should first be covered with about 4 in. of fuel and that the shavings, wood or material that was used to ignite the fuel should be placed near the bridge-wall and the fuel allowed to ignite from the top and burn gradually over toward the front of the grate. In this way all the volatile matter must pass through a heated zone before getting to the boiler-heating surface. In cleaning a fire Mr. Monnett urged that the fire be pushed over to one side, winged over, the ashes dumped out or pulled out and fresh coal put on the grate and the fire winged back over on the green coal.

Wednesday noon Mr. Henderson, chief of the Bureau of Smoke Regulation, spoke on smoke abatement before the Rotary Club, Civic Club of Allegheny Co., and the Smoke and Dust Abatement League, at the Fort Pitt Hotel. Mr. Henderson told what had been done and what was contemplated. The united bodies voted there to give him their support.

As related to power-plant engineering, the most interesting talk of the week was given by Mr. Monnett, Wednesday evening, before the Engineers' Society of Western Pennsylvania, at the society's quarters in the Oliver Building. Here the speaker went into the question of combustion and showed with many lantern slides different designs of furnaces and the proportions and ratios that should be adhered to for smokeless operation. Nearly all of Mr. Monnett's talks, except of course the discussion that occurred after the lecture, has been covered by him in "Power."[2]

During the discussion, Henry Kressinger, engineer of the Bureau of Mines, told of investigations that had been conducted recently by the bureau for the purpose of determining the relative combustion spaces or furnace volumes required by coal having different amounts of volatile matter and other ingredients. The results of these investigations will soon be published in a bulletin to be issued by the bureau.

Thursday noon, H. H. Maxfield, superintendent of motive power, Western Pennsylvania Division, Pennsylvania R.R., spoke of railroad smoke abatement before the Credit Men's Association. This talk was indeed interesting, as it was made with the aid of a number of motion pictures which showed smoke-abatement work as it is done by that railroad. Mr. Maxfield told of being able to build a fire in a cold locomotive and getting that locomotive up so that it could be run under its own steam without making objectionable smoke, or in fact any but smoke of the very least density. It would be difficult to do this part of the talk justice in this account of the meeting, so it is intended to show in another article, to be published later, just how Mr. Maxfield's methods would be used when applied to a stationary boiler.

[1]Engineer, American Radiator Co.

[2]Mr. Monnett wrote many articles for "Power" on furnaces, stokers, breechings, stacks, etc., considered chiefly from the smoke-abatement standpoint, but which carefully considered and allowed for capacity and economy. These articles appeared from May 12, 1914, to Mar. 30, 1915.

Reduction in Rates for Electric Power in Brooklyn

By unanimous decision, the Public Service Commission on Oct. 27 ordered a reduction in rates charged for electric current by the Edison Illuminating Co., of Brooklyn, N. Y. The company is directed to reduce its retail rates from a maximum of 11c. per kw.-hr. for lighting and 10c. per kw.hr. for power to a maximum of 8c. per kw.-hr., with a corresponding reduction in other rates.

The new rates are to go into effect Dec. 1 and are to remain in effect for one year. The new maximum rates are

identical to those now in force in Manhattan, which were established by the Public Service Commission 18 months ago.

The 8c. rate is in force for the first 2 kw.-hr. average daily use per month. For the second 2 kw.-hr. 6c. is charged. The old charge of 4c. per kw.-hr. for all over an average daily consumption per month of 4 kw.-hr. is not changed. At the new rate the commission experts figure that the retail customers will be saved about $1,100,000 per annum and that the company will have a return of 7 per cent. on its investment as estimated by the commission.

The Edison company has claimed a capitalization value on its property of $38,000,000 throughout the lengthy fight, covering four years. This the Public Service Commission reduced to $22,000,000 and then figured that 7 per cent. was a fair return for the company to make. The commission also directed that while the company may charge 0.5c. per kw.-hr. for lamp renewals, it must furnish tungsten lamps or their equivalent in efficiency, instead of the gem or carbon lamp which it now gives. The company is allowed to make a minimum charge of $1 per month, but this must be credited up to the next month's consumption.

PERSONALS

Robert W. Rogers has recently accepted the position of chief engineer of the Superno Co., Inc., New York.

S. P. Blakeman, formerly with the Terry Steam Turbine Co., Hartford, Conn., is now mechanical engineer with the SKF Ball Bearing Co., of the same city.

Jiles W. Haney, formerly chief engineer of the Commerce Power Co., Kansas City, Mo., is now in the mechanical engineering department of Pennsylvania State College, State College, Penn.

Charles S. Kinnison, formerly Western advertising manager for the blast furnace and steel plant, has been appointed general sales manager for the Flota Mica Sales Co., with offices at 1201-03 Kresge Building, Detroit, Mich.

Joseph Harrington, of Chicago has been retained by the Inland Steel Co. to put in a big powdered coal installation which will serve a continuous rail-heating furnace and four 300-hp. boilers. About 80 tons of powdered coal per day will be required. The general arrangements and all details were designed by Mr. Harrington. It is estimated that the plant will be running about Dec. 15 and a successful performance will probably mean other installations of the same character throughout the works.

OBITUARY

Theodore N. Ely, engineer and retired chief of motive power of the Pennsylvania R.R., died at his home at Bryn Mawr on Oct. 28, in his seventy-first year. He spent his entire active life of forty-eight years in the employ of the Pennsylvania R.R., being chief of motive power of the entire system upon his retirement from active service about five years ago.

Charles W. Hotchkiss, president and director of the Richmond Light & R.R. Co., died suddenly at Battle Creek, Mich., on Oct. 28, in his fifty-fourth year. Since his first railroad service with the New York, West Shore & Buffalo R.R. thirty-five years ago, he has been consecutively assistant engineer of the Michigan Central, chief engineer of the Chicago Junction Railway, president of the Indiana Harbor R.R., manager of the Chicago, Indiana & Southern R.R. and of the Indiana Harbor Belt R.R. Co. He was a member of many engineering societies and various engineering and social clubs. He is survived by his widow.

ENGINEERING AFFAIRS

The New England Water Works Association will hold its next meeting in Boston on Nov. 8, with headquarters at the Hotel Brunswick.

The Blue Room Engineering Society will hold its regular monthly business meeting and dinner at its headquarters, 103 West 38th St., New York City, on Thursday evening, November 9.

The Texas State Association of the N. A. S. E. will hold its convention at San Antonio, on Nov. 9, 10 and 11. President D. E. Claypole and the local committee have completed arrangements and a big meeting is expected.

The American Institute of Steam Boiler Inspectors of New York at the regular monthly meeting on Oct. 27 listened to an instructive talk by Franklin Van Winkle, associate editor of "Power" who explained by a blackboard talk some of the knotty problems often encountered by the boiler inspector.

The American Chemical Society will devote its next meeting, on Nov. 10 at the Chemists' Club, 50 East 41st St., New York, to a discussion of the chemist in public service. Among the speakers will be Prof. C. A. Beard, of Columbia University, Dr. Harvey W. Wiley, and Dr. Otto Klein, Director of the Central Testing Laboratory.

Proposed Construction

Calif., Portola—Walker Copper mine plans power plant.

Calif., Fontana—Fontana Co. has obtained permission from the State Railroad Commission to issue $350,000 bonds for a power plant to supply Fontana and Rialto with electric power, and to construct a 4½-mi. pipe line from Lytle Creek.

Idaho, Filter—Public Utilities Commission has granted certificate of public convenience and necessity to the Idaho Power Co. to construct an electric-light system.

Idaho, Wallace—Roberts-Inskip Co. made application for right to build a central heating plant and electric-light system.

Kan., Altoona—City making plans for electric-lighting system. About $22,000. Riley & Hardman, Parsons engineer.

Kan., Concordia—City to vote Nov. 10 on $10,000 bonds for completing the electric-light plant and system. Wayne Cully, Clk.

Kan., Independence—City Council plans election to vote on bonds for electric-light and power plant.

Kan., Viola—City Council granted franchise to Sumner Light and Power Co. to supply electricity for 20 years. Transmission line to be erected from Wellington to Viola.

Man., Grand Rapids—Manitoba Pulp and Paper Co. are having plans prepared for a dam and power plant.

Mass., Boston—City making plans for power plant. Wells & Dana, 29 Central St., architect.

Minn., Arlington—City plans improving electric-light plant and extending transmission lines. M. C. Meffert, Clk.

Minn., Jeffers—City making plans for electric-light system.

Mo., Ash Grove—Ash Grove Milling and Light Co. will construct a fire-proof power house and install new and complete equipment. W. B. Turner, manager.

Neb., Dunbar—City plans electric-light plant. Wilbur W. Anness and Cliff C. West, interested.

Neb., Ft. Calhoun—City Council plans street lighting system. Transmission line to be erected from Douglas County line to Ft. Calhoun.

N. J., Atlantic City—Breakers Hotel making plans for 1-story, 28x30-ft. addition to boiler plant. About $5,000. Smith & Henderer, Sheen Bldg., architect.

N. J., Woodbury—City Council plans electric-light plant.

N. D., Towner—T. K. Strand making plans for electric-light plant.

Ohio, Lowellville—Republic Railway and Light Co., Sharon, plans extensive improvements to power station at Lowellville.

Ohio, Middletown—The Ohio Gas and Electric Co. will install a transmission line from Cincinnati. Estimated cost, $90,000.

Ore., North Bend—Oregon Power Co. authorized to erect new 11,000 volt transmission line between C. A. Smith Mill and company's substation at Porter. About $18,000. F. C. Burke, Supt.

Penn., Millersburg—Millersburg Electric Light, Heat and Power Co. plans to construct a lighting plant.

S. D., Clark—City Council considering franchise to install electric-light system. About $30,000.

Tenn., Memphis—Bd. City Commissioners receiving bids Nov. 14 for purchase of $1,500,000 bonds for electric-light plant. J. H. Weatherford, City Engr.

Tex., D'Hanis—City plans electric-light plant.

Tex., La Pryor—R. L. Couser and W. L. Tittsworth plan to install an electric-light plant.

Tex., Thornton—Thornton Business Club considering plans for electric-light plant.

Vt., Montpelier—Addison Electric Power Co. recently incorporated with capital stock of $500,000 plans power station on Leicester River.

Wash., Cle Elum—City Council plans to install an electric-light plant.

Wash., Pe Ell—North Coast Power Co., Centralia, plans distribution system. About $15,000. B. C. Condit, chief engineer.

Wis., Burlington—Wisconsin Gas and Electric Light Co. plans to extend transmission line to south shore of Brown's Lake.

Wis., Wilton—Wilton Light and Power Co. making plans for hydro-electric plant.

Wyo., Greybull—Albert A. Bent, Denver, Colo., has been granted a franchise to build an electric-light plant.